RADIODONTIA

(DENTAL RADIOGRAPHY AND DIAGNOSIS)

QUESTIONS AND ANSWERS

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(Dental Radiography and Diagnosis)

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BY

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ILLUSTRATED

BROOKLYN, NEW YORK

DENTAL ITEMS OF INTEREST PUBLISHING CO.

LONDON

CLAUDIUS ASH, SONS & CO

1923

Press of
J. J. Little & Ives Company
New York, U. S. A.

TO

FANNIE AGNEW RAPER

who has made possible this
book and all other work I have
done in recent years

PREFACE

Broadly speaking, the study habit itself is simply the habit of asking one's self questions; then looking up the answer.

This book is intended for students of radiodontia, both graduates and undergraduates.

Radiodontia as a branch of dentistry is passing through a critical stage in its development. There is a great deal more to radiodontia than the mere mechanics of making X-ray pictures, though this fact is not widely appreciated. It is the connecting link between dentistry and the science of medicine. To fail to know something of radiodontia in its true scope is to fail to know what modern dentistry is all about.

The questions-and-answers form of presenting a subject is commonly considered less dignified than the narrative form. Yet the style of the answers is often quite similar to that of a dictionary, and whoever accused a dictionary of being undignified? Whether dignified or not, the questions-and-answers form is certainly *very different* from the narrative form; and my experience as a teacher is that *all* methods should be employed if the teacher really wants to "get his subject over to his students." Hence this volume.

It has been the aim of the writer to make the answers as spontaneous and brief as possible. It is my hope that what this style may lack in formality it makes up for in its spontaneity; it is unquestionably true that a spontaneous brief answer may sometimes be more illuminating than a more labored, more meticulous one. While I have tried to hold on to the desired spontaneity and brevity throughout, still some of the more complicated and exacting parts of the book have had to be edited and rewritten repeatedly for the sake of accuracy.

A *few* questions are repeated, in different chapters. The reason for this is to establish a certain degree of continuity between questions, to bring out correlated information in convenient juxtaposition.

The questions-and-answers form is a convenient one; the reader may glance at the question; then, if he is sufficiently interested, read the answer.

By adopting this method of presenting the subject I have been able to include a great deal in a comparatively small space and also I have been able to incorporate the newer ideas and methods and get the book to the profession quickly—to serve the ideas "hot" so to speak.

The last chapter contains some elementary principles of medical diagnosis, i. e., the significance of blood pressure, blood counts, etc. It is not at all the purpose of the writer to teach the dentist or radiodontist medical diagnosis, and so make him independent of the attending physician, but instead, to impart information which will make coöperation with the medical internist mutually more satisfactory.

Neither is it the intent of the writer to offer this book as a substitute for the formal text and reference book; it does not completely take the place of the profusely illustrated book written in the narrative style. But I believe this sort of a volume has its place (its own place) as a means of teaching the subject.

From a technical pedagogical standpoint, there is much to be said in favor of this departure from the traditional text book method of presentation. It arouses the student's self-activity. The question is asked and, in an analytic way, the answer is presented. This is in accord with the development of modern teaching methods, since the analytic (inductive) process in teaching has, to a great extent, supplanted the synthetic (deductive) within the past two decades. The student is stimulated to ask for reasons and processes rather than to merely accept that which is presented. He is less apt to remain in a passive condition, receiving the information in a matter-of-course, indifferent manner.

The questions are asked according to a logical arrangement, being developed in increasing complexity, beginning with the simple and going to the more complex. In brief, the questions are asked in the manner they would be asked by a developing student himself. This principle of pedagogy—proceeding from the simple to the more complex—is, naturally enough, further illustrated through the book in the presentation of the answers themselves, for an attempt is made to present that which is new in terms of that which is already known. All material is presented in the light of analysis in so far as the question method is concerned. The analytic mind is always inquiring, "why," "what," "where," et cetera, and modern pedagogy has consistently advocated this phase of learning as making possible better assimilation and retention.

The desirability of recitations and examinations is obvious. Psychologically and pedagogically speaking, an impression without expression is extremely vague. (That is why, incidentally, teaching teaches the teacher.) After studying theory there is no test of having assimilated unless we express ourselves.

I suggest to college teachers of radiodontia that assignments may be made and the students called upon for recitation. The teacher may then, if he wishes to, elaborate on the answers with further explanation, black-

board drawings, clinics, etc. Numbering the questions—each chapter separately—will assist in making the desired assignments. In this way, individual teachers may conveniently designate the questions they wish to ask and eliminate those they wish to eliminate.

The usual objection to the questions-and-answers book as a means of teaching college students is that "the student simply learns to parrot his reply." But it is better that a student be able to answer parrot-like than that he should not be able to answer at all. For if he answers at all, even though it be parrot-like, there is a chance that the meaning of what he is saying may percolate into his understanding, a chance which is entirely non-existent if he cannot answer at all.

A verbatim answer however is not necessarily a parroted answer. The student may think in the same terms as those used in the text. Verbatim answers are neither particularly desirable nor particularly undesirable. I have heard students complain of professors who would not allow them to answer in their "own words." But most of these complaints came from students whose "own words," in the class room, were either unintelligible or revealed a distressing lack of understanding. Few teachers really care whether an answer is couched in the language of the text, or parts of the text with parts of the student's "own words," or purely in the words of the student. What they do insist on is that the answer be free of ambiguity and show a distinct and accurate understanding. Students have been known to "stall"; that is, to talk, just talk, in their "own words," and many of them, pretending a knowledge and a sincerity which in fact is wholly lacking. Too much of this sort of thing may make some professors weary, and they may then, in self-defense, insist on verbatim answers. Briefly stated, exact and illuminating replies in the student's "own words" are most desirable, but, like other particularly desirable things, they are rather difficult to obtain.

The reader will notice that in some places in the book there is a good deal of mathematics. It is not the writer's desire to load the reader's mind with a lot of figures to be remembered, but only to teach the principles involved. I recommend to teachers of radiodontia that it would perhaps be better to eliminate some of the more complicated mathematical questions from their assignments. Because radiography itself is not a mathematical science the figures used in connection with it are often inexact.

"The Analysis of the Book for the Benefit of the Busy Reader," printed here in the prefatory pages, is intended to give the "Busy Reader" a moderately accurate idea of the contents of each chapter in the fewest possible words.

PREFACE

The alphabetic index in the back of the book is calculated to enable the reader to locate 'most anything he wishes to "look up" with comparative ease.

It is a pleasure to acknowledge my indebtedness and extend my thanks to my highly esteemed and talented colleagues, Dr. C. O. Simpson, Dr. L. S. Peters, and Major Carl Darnell for their valued advice and criticism.

H. R. R.

Indianapolis and Albuquerque, 1923

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This chapter deals with the fundamental principles governing the time of exposure necessary to make radiographs; then passes into the mathematics of exposure. When one tries to apply the very exact science of mathematics to the very inexact science of radiography the effort is likely to prove exasperating and none too fruitful of satisfying results. Nevertheless considerable progress has been made in the mathematical estimate of the time of X-ray exposure for radiographic work and so it should be set forth here. The mathematical principles discussed are of more importance than the figures given.

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At last we are commencing to actually learn some of those obvious things about radiodontic technic which have more or less escaped our comprehension for years: for example, that the X-ray angle can be varied in only two ways, either vertico-horizontally or mesio-distally. Radiodontic technic is "settling down." The old empirical methods of making radiographs of the jaws and teeth are passing and our methods are becoming better systematized, or if you prefer the word, standardized. The position of the patient's head, the angle of the X-rays, and the position of the film in the mouth, are more accurately under our control. Such instruments as the Horizontal Occlusal Plane Finder, the Angle

Meter and the Set of Universal Filmholders greatly promote our efforts toward standardization. A rather important chapter, this one.

CHAPTER XI

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CHAPTER XII

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There is no such thing as an absolutely definite erythema X-ray dose. Different operators differ greatly in their estimate of the dose, some giving twice as much as others. The average estimated dose today is far less than the average estimated dose of five years ago. In the past the dose was doubtless overestimated. In a worthy effort to "play safe," it is probably underestimated, for the most part, today.

The fortunate fact is that, in the ordinary routine of practice, operators almost never give an excessive dose for radiodontic purposes. However, it has been rather common to give an epilating dose in an effort to make an anteroposterior radiograph of the antra, and the epilating dose is not far this side of the erythema dose.

The factor of safety against burning patients has been greatly raised for dentists by the replacement of the old gas tube dental units with the Coolidge tube units. When the penetration of the gas tubes of the old units dropped, the operator tried to make up for this by increasing his time of exposure; the penetration of Coolidge tubes remains practically constant.

In this chapter, as in Chapter VIII, we perforce try to apply the exact science of mathematics to the art of radiotherapeutics. This is necessary, but not particularly satisfying.

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Also an important chapter. The subject is here handled verbally, as distinct from the pictorial manner in which the writer handled it in "Elementary and Dental Radiography." The questions-and-answers form lends itself readily to college class work and is thought-stimulating.

CHAPTER XVIII

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A very large book might be written on the subject covered in this chapter. Obviously, then, the chapter touches only the "high spots." It touches a good many "high spots," however.

Some will consider this the most important chapter in the book. It sets forth information concerning the pulse, the temperature, blood count, blood pressure, urine analysis, and other special laboratory tests, and deals with the relationship of these things to oral infection and disease.

RADIODONTIA

QUESTIONS AND ANSWERS

CHAPTER I

TERMINOLOGY

Q. What is radiodontia?

A. Radiodontia is the science and art of making and interpreting radiographs of the teeth and contiguous parts.

Q. What is a radiodontist?

A. One who practises radiodontia. A specialist in radiodontia is one who limits his practice to the making of radiographs and dental diagnoses.

Q. What is a radiodontic examination?

A. A *radiodontic examination* is an examination of the mouth, teeth and jaws, wherein the X-rays have been made to give *all* the information they are capable of giving. (Thus it will be seen that an X-ray negative or set of negatives is not necessarily a radiodontic examination).

Q. What are radiographs?

A. Radiographs are X-ray photographs.

Q. What are some synonyms for the word radiograph?

A. Roentgenograph, Roentgenogram, skiagraph, skiagram and radiogram.

Q. What is a radiogram?

A. Wireless message, also X-ray picture.

Q. What is radiology?

A. The study of rays, including X-rays, ultra-violet rays, all sorts of rays, embracing everything relating thereto. In its more restricted sense: The study of the X-rays only.

Q. What is a radiologist?

A. In its restricted sense a physician or dentist who uses X-rays, particularly one who limits his practice to their use.

Q. What is meant by radioparent?

A. Transparent to the X-rays.

Q. What is meant by radiolucent?

A. Translucent to the X-rays.

Q. What is meant by radiopaque?

A. Opaque to the X-rays.

Q. What is a radiolucent spot?

A. A dark spot in a radiographic negative representing a spot of radiolucency in the object radiographed.

Q. What is meant by Roentgen ray?

A. Same as X-ray.

Q. What is a radiographer?

A. One who makes radiographs.

Q. What is a radiomount?

A. A mount made variously of combinations of glass, celluloid, cardboard, and the like, in which dental X-ray negatives are placed systematically and anatomically for convenience in reference and handling.

Q. What is radiodermatitis?

A. Inflammation of the skin caused by the X-rays or radium.

CHAPTER II

ELECTRICITY

Q. What is electricity?

A. Electricity is a form of energy.

Q. What is an electric conductor?

A. An electric conductor is a substance which carries electricity. If the electrical pressure is sufficient most any material may be made to carry electricity. An electric conductor is a material which carries electricity *readily*. For examples, silver and copper.

Q. What is a non-conductor?

A. A non-conductor is a substance which carries electricity very reluctantly, such as glass and wood. There is no such thing as an absolute non-conductor, if conditions are right and the electric pressure is great enough.

Q. Name two kinds of electric current.

A. The direct (D. C.) and the alternating (A. C.).

Q. What is a volt?

A. A volt is the unit of measurement of electrical pressure. We say so many volts pressure just as we would say so many pounds pressure in hydraulics.

Q. What is a kilovolt (Kv.)?

A. A kilovolt is 1000 volts.

Q. What is an ohm?

A. An ohm is the unit of measurement of resistance to the flow of electricity.

Q. What is an ampere?

A. An ampere is the unit of measurement of quantity of electricity. We say so many amperes just as we say so many square inches in the cross section of a water pipe.

Q. What is a milliampere (ma.)?

A. One thousandth ($1/1000$) of an ampere.

Q. What is magnetism?

A. Magnetism is a form of energy very closely related to electricity. Magnets are a part of electricity-producing machines, i. e., dynamos.

Q. What are dynamos or generators?

A. Dynamos or generators are electricity-producing machines. These machines produce our commercial electric currents.

Q. What is an electrical circuit?

A. Electricity is presumed to flow in a circle, that is from a starting point around a circle back to the starting point, thus completing a circuit.

Q. What is the function of the transformer seen on telegraph poles?

A. To reduce a high voltage to a lower one.

Q. What voltages are ordinarily supplied commercially?

A. A hundred and ten, or double that amount, i. e., 220. Voltage varies at different times during the day and night. Thus a 110 volt circuit at times is only 100 volts while at other times it may be 120. This instability of voltage is called "line fluctuation" and "line variation."

Q. What amperage is ordinarily supplied commercially?

A. Most any amperage desired, from a fraction of an ampere to over a hundred. The capacity for an ordinary dwelling house for example is usually about ten.

Q. What is meant by the "line current"?

A. The current in the mains, i. e., the wires which bring the current to the consumer.

Q. What is meant ordinarily when one speaks of "an increase in current"?

A. An increase in amperage, i. e., in amount of current as measured in amperes. It is not an exact mode of expression.

Q. What is a high tension wire?

A. A wire carrying a high tension current—i. e., a current of high voltage. The wires connected with X-ray tubes are high tension wires.

CHAPTER III

ACCESSORY ELECTRICAL APPARATUS

Q. What is a switch?

A. The electric circuit must be a continuous unbroken path. An electric switch is a convenient mechanical means of opening (breaking) and closing any particular circuit, thus throwing the electric current into or out of any circuit. To elucidate: Imagine a primary circuit from the power house where the electricity is generated down a certain street and back toward the power house. From this primary circuit extends numerous circuits into each house (and back to the mains). And each house circuit is subdivided into numerous extended circuits into lights, and irons, and fans, etc. Each of these extension circuits is controlled by a switch.

Q. What is a fuse?

A. A fuse is a piece of metal of definite size and fusing point capable of carrying only a certain amount (or quantity) of current, i. e., a certain number of amperes. If the capacity of the fuse is exceeded the metal melts and so the circuit is broken. A fuse is an electric safety valve.

Q. What is insulated wire?

A. Insulated wire is wire covered with material which is a non-conductor of electricity. This material is called "insulation." One may handle insulated wire without receiving an electric shock. Ordinary electric light "cord" is insulated wire.

Q. What is a rheostat?

A. A rheostat is a mechanical device by means of which the amount of current entering a machine—X-ray machine or other electrical machine—may be controlled. It corresponds to the faucet in hydraulics. Some rheostats act also as a switch.

Q. What is a transformer?

A. A transformer is an electric apparatus by means of which voltage may be changed.

Q. What is a step-down transformer?

A. A step-down transformer is a transformer which lowers voltage. Such transformers may be seen as large iron boxes on "telegraph poles." They change the high tension (i. e., high voltage) current from the power house to the usual 110 volts for ordinary commercial purposes. In point of fact the so-called 110 volt circuit varies from about 100 to 125 volts.

Q. What is a step-up transformer?

A. A step-up transformer is a transformer which raises voltage. X-ray machines are step-up transformers. They take the ordinary commercial current of 100 to 125 volts and raise the voltage to 45,000 or 60,000 or more.

Q. Say something about the construction of transformers.

A. In principle of construction a transformer consists of a core of soft iron about which is wrapped insulated wire, *the primary winding*. Over this winding is placed another winding of insulated wire, *the secondary winding*. There is no electric connection between the primary and secondary windings.

The primary current (i. e., the current the voltage of which is to be changed) passes through the primary winding and out again. As this occurs a current of electricity is induced or generated in the secondary winding.

When the wire of the secondary winding is shorter and of a larger gauge than that of the primary the transformer is a step-down transformer—i. e., one which lowers voltage, and incidentally raises amperage. When the wire of the secondary winding is longer and of a smaller gauge than that of the primary the transformer is a step-up transformer—i. e., one which raises voltage, and lowers amperage.

Q. What is an interrupter?

A. An interrupter is an electrical device by means of which a direct current is converted into an interrupted one.

Q. What is a rectifier?

A. A rectifier is an electrical device by means of which an alternating current is converted into a direct one.

Q. What is a rectifying switch?

A. A rectifying switch is a revolving switch by means of which an alternating current is changed into a direct one. Rectifying switches are used on "interrupterless transformer" X-ray machines.

Q. What is a rotary converter?

A. A rotary converter is a combination electric motor and generator on the same shaft, by means of which the alternating current may be used to generate a direct current or vice-versa.

Q. What is an auto-transformer?

A. The auto-transformer is a device for regulating the voltage through Coolidge X-ray tubes. Physically, the auto-transformer is a transformer with an electric connection between the primary and secondary windings. Functionally, the auto-transformer may be considered a sort of combination rheostat and transformer.

Q. What is meant by "line fluctuations?"

A. The line current is the supply current. "Line fluctuations" are small changes in voltage occurring within the space of seconds. Line fluctuations of 5% are common.

Q. What is meant by "line variations?"

A. "Line variations" are greater changes in voltage occurring over periods of time ranging from several minutes to hours. Line variations of 10% (above and below normal) are common. (Though there is, strictly speaking, the difference indicated above in the meaning of the words fluctuation and variation as used here, the words are nevertheless used interchangeably).

Q. What effect do line *fluctuations* and *variations* have on the current passing through the Coolidge X-ray tube?

A. Line variations and line flunctuations cause a magnified change in the temperature of the filament which in turn causes change in the quantity of X-ray generation.

Q. What is a stabilizer?

A. A stabilizer (the writer has in mind the Victor-Kearsley stabilizer) is an automatic device by means of which the current passing through a Coolidge X-ray tube is held constant in spite of line fluctuations and variations.

CHAPTER IV

X-RAY MACHINES

Q. At what voltage is the commercial current usually supplied?

A. Usually 110. Can be obtained at 220.*

Q. At what amperage is the commercial current usually supplied?

A. Most any amperage desired from a fraction of an ampere to 100 or 200.

Q. What voltage is required to produce X-rays suitable for ordinary radiographic work?

A. From about 45,000 to 60,000 volts. (The modern "deep therapy" X-ray machines generate voltages of 200,000 and even more).

Q. What amperage is required for ordinary radiographic work?

A. From about 10 to 30 milliamperes.

Q. Name the types X-ray machines in the order in which they have appeared on the market.

A. (1) Static machines. (2) Induction, or Ruhmkorff coil. (3) High-frequency or Tesla coil. (4) Interrupterless transformer. (5) Coolidge units.

Q. What is the status of the static machine?

A. Obsolete. (The static machine is the old X-ray machine with the big glass disks.)

Q. What is the status of the induction coil and tne high frequency coil?

A. The interrupterless transformer and the Coolidge units have pushed the induction coil and high-frequency coil off the American market. (The induction coil once had a very high standing as an X-ray machine.)

Q. What is the status of the interrupterless transformer?

A. Everything considered the writer considers the interrupterless transformer the best type of X-ray machine today (1923).

* Answered more fully in Chapter II.

Q. What is the status of the Coolidge units?

A. The Coolidge units are an excellent type of X-ray machine. Their only competition today is the interrupterless transformer.

Q. Compare the relative advantages and disadvantages of the interrupterless transformer and the Coolidge unit.

A. The advantages of the transformer over the Coolidge unit are: (1) Either the gas X-ray tube or the Coolidge X-ray tube may be used with the transformer while only the Coolidge X-ray tube may be used with the Coolidge unit. (2) More extensive adjustments may be made with the interrupterless transformer. That is to say it is more flexible and adaptable.

The advantage of the Coolidge unit over the interrupterless transformer is simplicity of operation.

Q. Name the different types of Coolidge units.

A. (1) The army unit. (2) The dental unit. (3) The bedside unit. (A very misleading name; for these units as used are really office units). (4) The portable unit. (5) The Coolidge oil-immersed dental unit.*

Q. Describe the army Coolidge X-ray unit.

A. Roughly the army Coolidge X-ray unit consists of a gasoline engine, an electric generator, a step-up transformer and a self-rectifying Coolidge X-ray tube.

Both the dental unit and the "bedside" unit are outgrowths of the army unit.

Q. Describe the dental unit.

A. The Coolidge dental X-ray unit consists primarily of a step-up transformer, with switch and current regulating device, and a self-rectifying X-ray tube.

* As this is written, the Coolidge oil-immersed dental unit is just ready for the market. It represents a radical departure in X-ray machine construction. A metal box, size about 8 inches by 5 inches by 7 inches contains the transformer and X-ray tube, immersed in oil. The X-ray tube is only 4¾ inches long with a bulb of only 1¾ inches in diameter. The metal box is held in an adjusting apparatus somewhat similar to the wall brackets which hold dental engines. The outfit has a stabilizer; also an insulation-installation transformer. There is only one electrical control, an on-and-off time switch. The X-ray voltage and milliamperage are the same as for the other Coolidge dental units. That is to say, the tube takes about 45,000 volts (3-inch back-up) and 10 milliamperes.

Q. What is the capacity of the Coolidge dental unit?

A. The capacity of the dental unit is about 45,000 volts, and 10 milliamperes delivered through the X-ray tube. Another way to indicate the voltage is to express it in terms of parallel spark back-up. Forty five thousand volts is equivalent to a "3-inch back-up."

Q. Is the Coolidge dental unit with the capacity of 45,000 volts only, suitable for both intra-oral and extra-oral work?

A. It is debatable if the penetration is sufficient to do the best extra-oral work possible. (Double intensifying screens with duplitized films may be used to shorten the time of exposure. Great improvement in the quality of intensifying screens has been made in recent years.)

Q. Describe the Coolidge bedside unit.

A. The Coolidge bedside unit is in general principle like the dental unit. The chief difference lies in the respective capacities of the two machines.

Q. What is the capacity of the Coolidge bedside unit?

A. Voltage about 60,000 (i. e., a 5-inch parallel spark back-up) and 10 to 30 milliamperes. (Uses either the 5-30 or the 5-10 Coolidge radiator tube. See Chapter V on X-ray tubes.)

Q. Can the voltage through the tube be regulated with an interrupterless transformer?

A. Yes.

Q. Can the voltage through the tube be regulated with a Coolidge unit?

A. The bedside units of some makes have voltage controls on them, others do not.

Q. What kind of electric currents do the following X-ray machines produce for tube excitation? (1) Interrupterless transformer. (2) Coolidge unit. (3) Induction coil. (4) High-frequency coil.

A. (1) Interrupterless transformer: Absolutely unidirectional current of suitable voltage and milliamperage.

(2) Coolidge unit: A current of suitable voltage and milliamperage but alternating. The Coolidge tubes used on the Coolidge units are said to be self-rectifying. That is to say they allow current to pass through them in one direction only.

(3) Induction coils: Almost unidirectional current but with a little

"inverse current." Is of suitable voltage and milliamperage. (Somewhat higher voltage and lower milliamperage than the interrupterless transformer as a rule.)

(4) High-frequency coil: Suitable voltage and milliamperage, but capacity quite limited. Current alternates at very high rate.

Q. When is a separate rotary converter placed between an X-ray machine and the source of electric supply and why?

A. When the commercial supply current is direct and the type of X-ray machine is Coolidge unit or high-frequency, to generate an alternating current which is necessary for these machines.

Q. What information does the X-ray manufacturer require when he is about to supply an X-ray machine and where may this information be obtained?

A. The information may be obtained from the Light and Power Company which supplies one's current. Learn the voltage, and whether the current is direct (D. C.) or alternating (A. C.). If A. C. learn the *frequency* and *phase.* (The voltage is usually about 110, the frequency or cycle, 60, and the phase, single.)

Q. How did X-ray machines used to be rated?

A. X-ray machines used to be rated according to the width of their parallel spark gap. That is according to the number of inches of atmosphere their secondary, i. e., X-ray, currents could jump. Thus we used to hear of "7-inch X-ray machines," "10-inch X-ray machines," "20-inch X-ray machines" and so on, the number in inches indicating the length of the parallel spark-gap. (When electricity jumps through the air a spark occurs.)

Q. What is the maximum parallel spark-gap ever needed for dental radiographic work?

A. For ordinary dental work the spark-gap needed ranges from about 3 to 5. For antero-posterior antrum radiographs a 5-inch gap is the minimum.

Q. What is the usual maximum parallel spark-gap for medium sized X-ray machines made for radiographic purposes today?

A. About 7 inches.

Q. What type of X-ray machine does not have a parrallel spark-gap?

A. The Coolidge unit type. (Also the old gas tube dental units now off the market.) These machines are rated according to the maximum

voltage they supply to the X-ray tube. Thus we have the 45,000 volt machine and the 60,000 volt machine. Instead of expressing this voltage in volts or Kilovolts it is usually expressed in spark-gap inches. So instead of saying a 45,000 volt machine we say a 3-inch machine, instead of saying a 60,000 volt machine we say a 5-inch machine. The time may come, however, when we will express voltage in volts or Kilovolts instead of spark-gap inches.

Q. Is the parallel spark-gap an accurate means of measuring voltage?

A. No. Different atmospheric conditions will make a difference in the number of inches of atmosphere a given voltage will jump. A spark-gap between spheres is more accurate than one between points.

CHAPTER V

X-RAY TUBES—GAS, COOLIDGE

Q. What is an X-ray tube?

A. An X-ray tube is a bulbular, glass vacuum tube, from which emanates X-rays when a current of electricity is passed through it.

Q. How may X-ray tubes be classified according to the fundamental principle of construction?

A. Gas tubes and Coolidge tubes. Coolidge tubes may be considered ionic, or better, electronic tubes.

Q. How do gas tubes and Coolidge tubes differ in fundamental principle of construction?

A. The vacuum of the Coolidge tube is substantially perfect and no current at all can be passed through it until the little coil of tungsten inside the tube is heated. The vacuum of the gas tube is less perfect; gas tubes contain enough gas to form a conductor for the current through the tube. The conductor for the current through the Coolidge tube is not gas but electrons created by the heated tungsten coil or filament.

Q. Name some different kinds of gas tubes.

A. Helium tubes, hydrogen tubes, nitrogen tubes and "ordinary gas tubes."

Q. Make a line drawing of a gas X-ray tube showing the following: (1) Cathode. (2) Anode or target. (3) Regulating chamber. (4) Assistant anode. (5) Adjustable arm and tube-regulating spark gap.

A. See Fig. 1. (By a connection with the tube-regulating chamber the tube-regulating spark gap may be transferred from the tube to the X-ray machine. Thus the sparking is made to occur at the X-ray machine instead of at the tube.)

Q. Which direction does the current pass through an X-ray tube?

A. From anode to cathode.

Q. How is degree of vacuum of an X-ray tube (or to be more exact resistance to the passage of current through it) indicated?

A. By the parallel spark-gap back-up.

Q. What is meant by "a 4-inch back-up?"

A. An X-ray tube is said to have a 4-inch back-up when its resistance to the passage of electricity is *slightly* more than the resistance of a 4-inch gap of atmosphere.

Q. If an electric current is offered two paths, one through a 4-inch gap of atmosphere and the other through an X-ray tube with a 4-inch back-up, which path will the current select and why?

A. The path through the 4-inch air gap, because it is the path of least resistance, and electricity always follows the path of less resistance.

Q. If an electric current is offered two paths, one through a 4½-inch gap of atmosphere and the other through an X-ray tube with a 4-inch back-up, which path will the current select?

A. The path through the X-ray tube.

Q. What happens when electricity passes through the air?

A. A "spark" or flame occurs.

Q. Give an example in nature of electricity passing through the air.

A. Lightning.

Q. How may the vacuum or resistance to the passage of current be reduced in gas tubes?

A. By passing current through the tube-regulating chamber (Fig. 1) thus heating the regulating chamber and so liberating more gases in the tube.

Q. Trace the path of the current when it is used to reduce the vacuum of a gas X-ray tube.

A. The course of the current to lower the vacuum, and so the resistance, of a gas tube is as follows: From the positive terminal of the X-ray machine, through the anode, through the tube-regulating chamber, through the tube-regulating spark-gap, to the negative terminal of the X-ray machine. (Fig. 1.)

Q. In what important respect do hydrogen gas tubes differ from other gas tubes?

A. The vacuum of hydrogen X-ray tubes can be both raised and lowered. Ordinary gas tubes, now on the market, admit of regulation of vacuum downward only.

Q. How are gas tubes classified according to their degree of vacuum?

A. Into 3 main classes. (1) Soft, or low vacuum tubes. (2) Medium tubes. (3) Hard, or high tubes.

Q. What is the parallel spark-gap back-up of (a) soft tube (b) medium (c) hard tube?

A. (a) Soft tube: *about* 3 inches.
(b) Medium tube: *aoout* 4 or 5 inches.
(c) Hard tube: *about* 6 inches.

Any tube with less than a 3-inch back-up may be considered a very low or soft tube.

Any tube with more than a 6-inch back-up may be considered a very hard or high tube.

Q. What is a "cranky" X-ray tube?

A. A cranky X-ray tube is a gas tube, the vacuum of which fluctuates up and down without apparent cause. As gas tubes get old they get "harder" and "crankier." When the vacuum of a hard, "cranky" tube is reduced for radiographic work it may raise again before the exposure can be made.

Q. What is the focal spot?

A. The focal spot is a spot on the target from which the X-rays emanate.

Q. How are X-ray tubes classified according to the size of their focal spots?

A. Into 3 classes. Those with (1) broad (2) medium and (3) fine focal spots.

Q. What is the approximate diameter of the broad focal spot of a gas tube? What is the approximate diameter of the medium and fine focal spots?

A. Broad about 8 millimeters.
Medium about 4 millimeters.
Fine about 2½ millimeters.

The size of the focal spot is said not to be constant in gas tubes as it is in Coolidge tubes. The size increases (probably) as the milliamperage increases.

Q. What effect does the size of the focal spot have on radiographs?

A. Other things being equal, the smaller the focal spot, the sharper the outline of the radiographic image.

Q. How does the size of the focal spot influence the amount of current, i.e., the milliamperage, which may be used through a tube?

A. The tube with the fine focal spot cannot take as much milliamperage over as long a period of time as the medium or broad focus.

Q. Why is it a fine focus tube cannot take as much current as tubes with medium and broad focal spots?

A. Because of the danger of burning the target at the focal spot.

Q. Does *slight* burning or etching of the focal spot ruin the tube for radiographic purposes?

A. No.

Q. What focal spot is best for dental work?

A. Fine.*

Q. How may gas X-ray tubes be classified according to size?

A. Gas X-ray tubes are classified according to the diameter of their bulbs. Thus we have 3, 4, 5, 6, 7 and 8-inch gas X-ray tubes.

Q. What size gas X-ray tube is best for radiographic work?

A. Seven inches is about the best.

Q. What objection is there to a gas tube with a small bulb?

A. It heats up quickly, and because the inside area of the tube is small a little variation of gas content has considerable effect on the degree of vacuum.

Q. How may gas X-ray tubes be classified according to the X-ray machine on which they are used?

A. (1) Transformer tubes. (2) Induction coil tubes. (3) High-frequency tubes. (4) Unit tubes.

Q. Is there any difference between transformer and induction coil X-ray tubes?

A. They are almost identical. The transformer tube is built to take a little more current (milliamperage) at a little lower pressure (voltage).

Q. What is the outstanding feature of the high-frequency X-ray tube compared to other tubes?

A. When electricity passes through a tube in one direction one cathode stream is generated, which cathode stream strikes the target at a point, the focal spot, from which point X-rays are given off. The high-frequency X-ray tube is built to take an alternating current—i. e.,

* The technic for measuring the focal spot is given in Chapter XI.

a current flowing in both directions. Two cathode streams are generated but the tube is built in such manner that only one of the cathode streams is used to generate X-rays.

Q. What is a unit or combination gas tube?

A. Before the advent of the Coolidge X-ray tube, there were X-ray machines on the market, with combination gas tubes, known as dental units. Since the advent of the Coolidge X-ray tube practically all dental units are Coolidge dental units. The old unit combination gas X-ray tubes usually had a small bulb—about 3 inches in diameter. They were made of lead glass save for a window of ordinary glass through which passed the X-rays needed for radiographic work. The type of X-ray machine construction for the old dental units was induction coil or high-frequency coil. When the construction was induction coil the combination tube included a valve feature to prevent any inverse current flowing the wrong way through the tube. The combination unit gas X-ray tube had a patent tube-regulating spark gap. Or to be more exact they had no tube-regulating atmospheric gap but instead a crude connection across the gap, this connecting device being adjustable to varying degrees of resistance. The gas dental unit outfit was not an auspicious success.

Q. Name two classes of Coolidge X-ray tubes.

A. Universal tubes and radiator tubes.

Q. What is the outstanding characteristic of the Universal Coolidge X-ray tube?

A. The Universal Coolidge X-ray tubes are those with the 7-inch (diameter) bulbs.

Q. How are the Universal Coolidge X-ray tubes classified?

A. According to the size of their focal spots into 3 classes (1) the broad focal spot (2) the medium focal spot and (3) the fine focal spot.

Q. Give the approximate diameter of the focal spots of the Universal Coolidge X-ray tube.

A. Broad about 10 millimeters.
Medium about 7 millimeters.
Fine about 5 millimeters.

Q. What is the outstanding characteristic of the Coolidge radiator X-ray tube?

A. The bulb is 3¾ inches in diameter and on the anode end of the tube is a series of copper disks, the radiator.

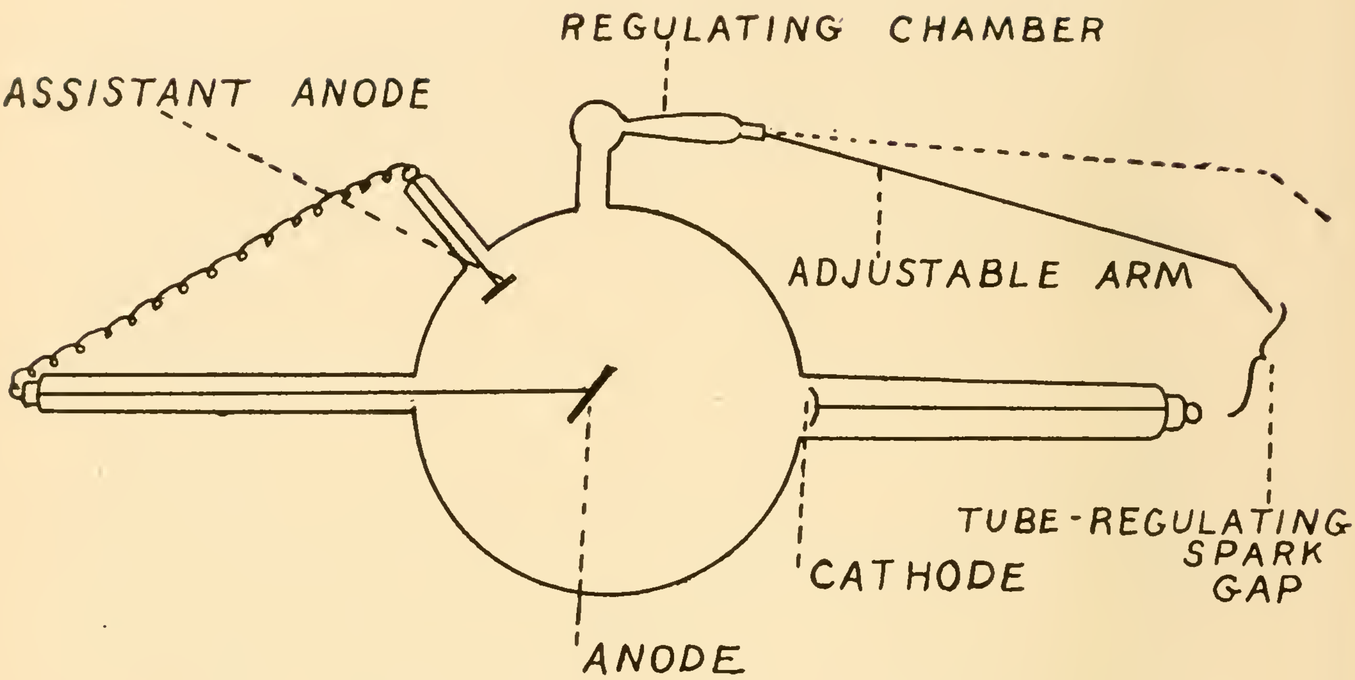


Fig. 1. Line drawing of ordinary gas X-ray tube showing important parts.

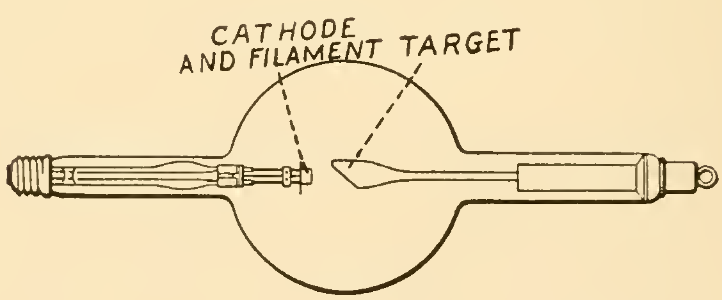


Fig. 2. Line drawing of a universal Coolidge tube.

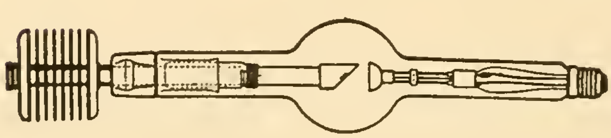


Fig. 3. Line drawing of a radiator Coolidge tube.

Q. How are radiator Coolidge tubes classified?

A. There are three kinds of radiator Coolidge tubes: (1) the 5-30 tube (2) the 5-10 tube and (3) the 3-10 tube.

Q. What is meant by a 5-30 radiator Coolidge?

A. The first number 5, indicates the spark-gap back-up. That is to say the maximum electric pressure which may be impressed through the tube is the same as the voltage required to jump a 5-inch atmospheric gap—i. e., about 60,000 volts.

The second number, 30, indicates the maximum milliamperage which may be passed through the tube when the pressure is at 60,000 volts. When the voltage is less than 60,000 more than 30 milliamperes may be passed through the tube.

Q. How may voltage be estimated from the spark-gap back-up?

A. Figure 20,000 volts for the first inch and 10,000 volts for each succeeding inch. Or another way to express the same idea is to say: Multiply 10,000 by the number of inches of the spark-gap and add 10,000. For example, the spark gap is say 3. Three times 10,000 is 30,000 plus 10,000 equals 40,000. A more exact way to estimate voltage from the spark-gap is to figure "15,000 each for the first three inches and 8,000 for each additional inch up to 100,000 volts." *

Q. What is meant by 5-10 radiator Coolidge tube?

A. A tube with a capacity of about 60,000 volts and 10 milliamperes. (See answer to the second preceding question, viz. "What is meant by a 5-30 tube?".)

Q. Is it ever permissible to pass more than the rated milliampere capacity through the 5-30 and the 5-10 radiator Coolidge tubes?

A. Yes, when less than the maximum voltage—i. e., spark-gap—is used. See following chart.

Tube	5″ Gap	4″ Gap	3″ Gap
5-30	30 ma.	37.5 ma.	50 ma.
5-10	10 ma.	12.5 ma.	17 ma.

Q. Is it ever permissible to use more than the rated voltage through a rated Coolidge tube?

A. No.

Q. What is meant by a 3-10 radiator Coolidge tube?

A. A tube with a capacity of 45,000 volts and 10 milliamperes.

* Darnell.

Q. What is the outstanding characteristic of the 3-10 radiator Coolidge tube?

A. The anode and cathode are at right angles to one another instead of parallel as in other tubes.

Q. Give a full descriptive name for the 3-10 Coolidge tube.

A. The 3-10, Coolidge, dental, right angle, X-ray tube.

Q. What is an outstanding characteristic difference in the appearance between a gas tube and a Coolidge tube?

A. The Coolidge tube has no tube-regulating chamber or assistant anode. (See Figs. 1, 2 and 3.)

Q. What is the size of the focal spot of the 5-30, the 5-10 and the 3-10 Coolidge X-ray tubes?

A. 5-30 tube, about 4.5 millimeters.
5-10 tube, about 3 millimeters.
3-10 tube, about 3 millimeters.

Q. What Coolidge X-ray tubes may be used for dental work?

A. (1) Universal tube, fine focus. (2) 5-30 radiator tube. (3) 5-10 radiator tube. (4) 3-10 radiator tube.

Q. Suppose a universal fine focus Coolidge tube fails to give sharp radiographic outlines, what is the probable cause and what may be done to correct the fault?

A. Failure to get clear, sharp radiographic outlines may be due to the size of the focal spot, the spot being a little too large. The fault may be corrected by increasing the distance between the target and the photographic film or plate during exposure—i. e., by moving the tube farther away from the patient. Also using a smaller diaphragm and a long compression cylinder.

Q. When we speak of a "5-inch tube" referring to a gas tube, what is meant?

A. A tube with a bulb 5 inches in diameter.

Q. When we speak of a "5-inch tube" referring to a Coolidge tube, what is meant?

A. A tube rated to take a maximum voltage equivalent to the voltage necessary for current to jump a 5-inch air gap—i. e., about 60,000 volts.

Q. What is meant by self-rectifying tubes?

A. Tubes which allow current to pass through them in one direction only. Coolidge tubes are self-rectifying tubes. When, from use, the

anode of the Coolidge tube approaches the same degree of heat as the tungsten filament the tube ceases to be "self-rectifying." Ordinarily gas tubes are not self-rectifying. However there are gas tubes which are said to have this self-rectifying feature. The combination gas X-ray tubes used on the first dental units of induction coil construction were said to be semi-self-rectifying.

Q. Give a "continuous running" rule for fine focus gas tubes.

A. Ten milliamperes at a 4-inch back-up, 5 second exposures with 30 second rest intervals.

Q. In the practice of radiography when the exposure necessary is longer than 5 seconds what is a good working rule to follow to avoid overheating fine focus tubes and burning the target?

A. Expose 5 seconds, rest 2 to 5 seconds, expose 5 seconds again, and so on. This is spoken of as the "interrupted exposure" or "interval exposure."

Q. For dental work what is a good (and safe) "working capacity" for (1) the universal fine focus Coolidge tube? (2) The 5-30 radiator Coolidge tube? (3) The 5-10 radiator Coolidge tube? (4) The 3-10 dental Coolidge tube? (5) The fine focus gas tube?

A. 1. The universal Coolidge: about 4½ inch gap. 25 ma.
2. The 5-30 radiator Coolidge: about 4½ inch gap, 25 ma.
3. The 5-10 radiator Coolidge: about 4½ inch gap, 10 ma.
4. The 3-10 dental Coolidge: 3-inch gap, 10 ma.
5. Fine focus gas tube: about 4-inch gap, 10 to 15 ma.

Q. What is the appearance of a gas X-ray tube in operation?

A. The active hemisphere—i. e., the half of the bulb in front of the target—lights up (fluoresces) a greenish color. Some greenish light can also be seen in other places in the tube, notably just back of the cathode.

Q. How does the color of a gas X-ray tube vary according to the degree of vacuum?

A. The higher the vacuum, the more yellow in the green. The lower the vacuum, the more blue in the green.

Q. Can the cathode stream be seen?

A. Ordinarily no, but in a very low vacuum tube it can be seen extending as a cone from the cathode to the focal spot on the target, the point of the cone at the focal spot. It is blue. (Fig. 4.)

Q. When a gas tube is punctured what color does it light?

A. It usually does not light at all. There may be some blue areas showing.

Q. What is the appearance of a gas tube with a lead glass bulb when the current is passing through it?

A. Such a tube lights up blue save for the window of ordinary glass, which is green.

Q. What is the appearance of a Coolidge X-ray tube in use?

A. It does not fluoresce green like gas tubes. One sees only the light of the tungsten filament. With use the target gets red hot.

Q. What gas tube may be used with the target red hot?

A. The Helium tube. The target should not be heated beyond cherry red as seen in ordinary room illumination.

Q. When should the vacuum of a gas X-ray tube be regulated —i. e., lowered?

A. Only when absolutely necessary. Unnecessary vacuum regulating shortens the life of the tube, the tube gets cranky sooner—i. e., the vacuum gets too high and unstable.

Q. Give specifications for ordering a gas tube for dental work.

A. Size: 7 inches. Focal spot: Fine. Vacuum: Pumped to take about 15 milliamperes with a back-up of about 3½ to 4 inches.

Q. What is the approximate milliamperage capacity with the spark-gap back-up 5 inches for the following tubes: (1) Gas tube with fine focal spot. (2) Gas tube with medium focus and (3) gas tube with broad focus?

A.
1. Fine focus: about 15 to 20.
2. Medium focus: about 40.
3. Broad focus: about 70.

Q. When using radiator Coolidge X-ray tubes what especial care should be exercised?

A. Do not exceed the rated voltage, expressed in spark-gap back-up, and milliamperage capacity.

Q. What is the capacity of the universal Coolidge fine focus tube?

A. Twenty five milliamperes at 5-inch gap and 15 milliamperes at 6-inch parallel spark-gap back-up.

Q. Give a "continuous running" rule for Coolidge tubes.

A. Coolidge tubes (the ones now made, 1923) may be operated indefinitely at capacity for 5 second exposures with 30 second intervals of rest.

CHAPTER VI

THE X-RAYS

Q. What are X-rays?

A. X-rays are electro-magnetic "waves" or rays identical essentially to ordinary visible light rays. Compared to visible light rays, X-rays are shorter and have a higher rate of vibration.

Q. Are X-rays and Roentgen rays the same?

A. Yes. Roentgen rays is simply another name for X-rays.

Q. Who discovered X-rays?

A. William Conrad Roentgen.

Q. Was Roentgen a graduate of medicine or dentistry?

A. No, he was a physicist. He taught physics at the Royal University at Würzburg, Germany.

Q. When were the X-rays discovered?

A. In 1895.

Q. Is it true that Roentgen discovered the X-rays by accident?

A. Different stories are told regarding the discovery but the fact is pretty well established that Roentgen discovered the X-rays by chance while passing an electric current through a Crookes vacuum tube pursuant to his work as a teacher of physics. Perhaps it would be more exact to say that Roentgen met with a lucky accident which *led* him to the discovery of the X-rays, for the discovery would not have been made, by Roentgen at least, had he not had the wisdom to follow the clue Fate gave him.

Q. What is a Crookes tube?

A. A Crookes tube is a vacuum glass tube made by Professor William Crookes, an Englishman, for the purpose of studying the phenomena incident to the passage of electricity through a vacuum. X-ray tubes of today are not, strictly speaking, Crookes tubes, though they are the outgrowth of the Crookes tube since Crookes was the first to make a tube which generated X-rays.

Q. Who was the first dentist to make an intra-oral X-ray picture of the teeth?

A. Dr. C. Edmund Kells, Jr., a dentist of New Orleans, within a year after the discovery of X-rays.

Q. Describe the manner in which X-rays are generated.

A. The electric current passes through the X-ray tube from anode to cathode. As a result of this, the *cathode stream* is generated which is a form of kenetic energy which travels from cathode to anode. The cathode stream is focused to strike the anode, or target, at a point—i. e. the focal spot or point. The X-rays emanate from the focal spot as a result of the impact of the cathode stream against the target. X-rays are given off from the focal spot in a regularly diverging, fan-like spread. (See Fig. 4.)

Q. Of what is the cathode stream composed?

A. Swiftly moving electrons.

Q. What is the difference between the cathode stream and the cathode rays?

A. No difference, they are the same thing.

Q. Can X-rays be seen?

A. No.

Q. Are X-rays discernible to any of the special senses?

A. No.

Q. Can X-rays be reflected?

A. No, except under unusual experimental conditions. However, when the X-rays strike and penetrate a surface, secondary rays are given off, which phenomenon is similar to reflection.

Q. Are secondary X-rays as strong as primary X-rays?

A. No.

Q. What is the significance of the X in the term X-rays?

A. The term X-rays was given by Roentgen. Roentgen did not know just what he had discovered. With commendable modesty and honesty he adopted the X, the algebraic symbol for the unknown, as the name for the new rays.

Q. How does the number of milliamperes passing through the tube affect the X-ray production?

A. The greater the number of milliamperes passing through the tube, the greater the number or quantity of X-rays generated.

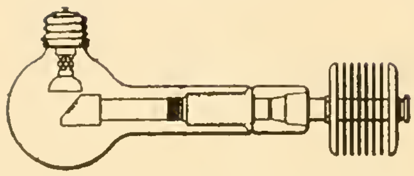


Fig. 3D. Line drawing of the Coolidge radiator right-angle dental X-ray tube.

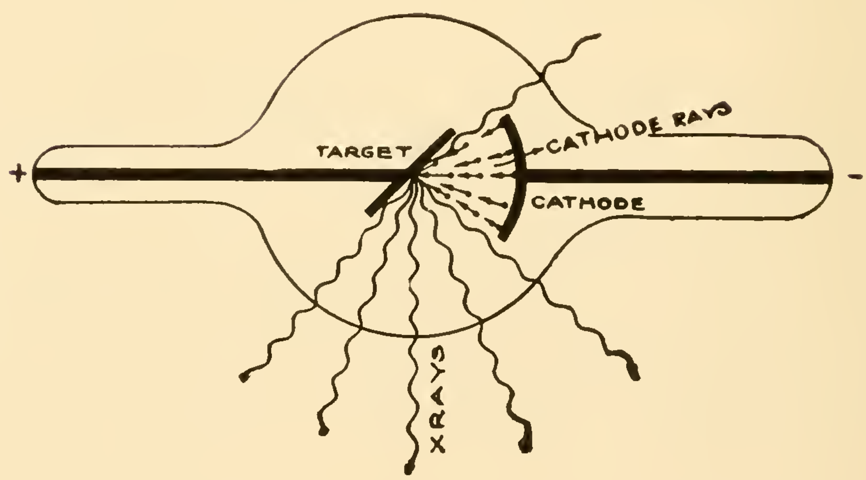


Fig. 4. Line drawing showing the cathode stream (also called cathode rays), indicated by the arrows, passing from the cathode and striking the target at a point, the *focal point*, usually referred to as the *focal spot*. X-rays are given off from the *focal spot* in regularly diverging lines. The *active hemisphere* of an X-ray tube is the hemisphere in front of the target, the hemisphere, that is, from which the X-rays emanate.

Q. How does the number of volts passing through the X-ray tube affect the nature of the X-rays generated?

A. The higher the voltage, the more penetrating the X-rays.

Q. On what does the "intensity" of X-radiation depend?

A. The milliamperage and voltage passing through the X-ray tube.

Q. How does the degree of vacuum of a gas tube affect the nature of the X-rays generated?

A. To say that the vacuum of a gas tube is high is but a way of saying that it requires a high voltage for such a tube in order to get current through it. Therefore a high vacuum tube, since it requires a higher voltage, generates very penetrating (i. e., "hard") X-rays and conversely a low vacuum tube, since it requires a comparatively low voltage, generates less penetrating (i. e., soft) X-rays.

CHAPTER VII

ELEMENTARY RADIOGRAPHY

Q. What is a photographic plate?

A. A photographic plate is a piece of transparent glass, one side of which has been coated with a gelatinous emulsion of a silver salt which coating has been allowed to dry and adheres tightly to the glass.

Q. What is a photographic film?

A. A photographic film is the same as a photographic plate except that, in the case of the film, thin transparent celluloid is used instead of glass.

Q. What is the appearance of a photographic plate when seen in ordinary light?

A. The plate has the appearance of a piece of translucent white glass. There is, however, a greenish yellow cast to the "white" of a photographic plate (or film).

Q. How are plates and films handled commercially?

A. They are packed in light-proof boxes which are to be opened only in a "photographic dark room."

Q. What is a "photographic dark room"?

A. Simply a room from which light is excluded and illuminated with a "dark room light".

Q. What is a dark room lantern?

A. A dark room lantern is a lantern which gives a ruby light which does not affect the silver salt emulsion on plates and films. Such a light is said to be "safe".

Q. What is a "safelight lamp"?

A. Same as dark room lantern.

Q. What effect does ordinary light have on plates and films?

A. It acts on the silver salt emulsion in such manner that when the plate or film is immersed in an aqueous solution of chemicals known as the developing solution, the emulsion turns black.

Q. What are actinic rays?

A. Actnic rays are those light rays which affect the photographic emulsion on plates and films.

Q. Are there any actinic rays in a "safelight"?

A. No, not if the light is actually safe.

Q. In what sizes and quantities are films and plates supplied?

A. Special size films for intra-oral dental work and also 5 x 7 inches, 6½ x 8½, 8 x 10, 10 x 12, 11 x 14 and 14 x 17. In packages of one dozen.

Q. What are duplitized films?

A. Films both sides of which are coated with sensitized emulsion.

Q. What is the sensitive side of a plate or film?

A. It is the side coated with the sensitized emulsion. (Also called "coated side" and "emulsion side.")

Q. Is there any difference between the ordinary photographic plate or film and an X-ray plate or film?

A. No fundamental difference. An X-ray picture can be made on an ordinary photographic plate and a photograph could be made on an X-ray plate.

However plates and films made specially for X-ray work are particularly sensitive, also especially contrasty.

Q. How can the sensitive side of a plate or film be distinguished from the non-sensitive side in practice?

A. Look at the plate or film in the safe light. The coated or sensitive side is less shiney than the other, the glass or celluloid side, due to the presence of the coating of the gelatinous silver salt emulsion. (Just the reverse of this is true in the case of the new Eastman "translucent" dental films. The celluloid of these new films is "frosted".)

Q. How are plates or films prepared by the operator to make X-ray pictures?

A. In a dark room, by the light of the safe light, place the film or plate in a black envelope, supplied by the manufacturer for the purpose, having the sensitive side present toward the smooth side of the envelope (not the seam side). Next place the black envelope containing the plate or film, into a red or orange envelope, open end of the envelope first, and be careful that the sensitive side of the plate still presents toward the smooth side—i. e., the non-seam side—of the second, the red or orange envelope.

Q. Why are the plates and films placed in *two* envelopes?

A. To protect them better against ordinary light.

Q. What are kassettes?

A. Kassettes are special containers made of metal or cardboard which may be used instead of the two envelopes just described. Kassettes, like the envelopes, must be "loaded" in the dark room by the light of the safe light.

Q. Will it harm the sensitive side of the plates and films to touch with the fingers?

A. Probably not if the fingers are *perfectly* dry and clean. *However* the fingers are so likely to be moist and oily that the operator should avoid touching the sensitive surface of plates and films.

Q. What two properties of the X-rays make radiography possible?

A. First, X-rays penetrate different substances differently, roughly, according to their density. Second, X-rays have the same effect on a photographic plate or film as ordinary light.

Q. What fundamental principle is involved in the making of radiographs?

A. The principle of shadow formation.

Q. What are the factors necessary to shadow formation?

A. Three, namely (1) a source of light, (2) an object, and (3) a screen on which the shadow may fall.

Q. What must be the relative position of light, object and screen, in order to cast a shadow?

A. The object must be between the source of light and the screen.

Q. In radiography what corresponds respectively to the source of light, the object and the screen or surface?

A. The X-ray tube corresponds to the source of light.

The part of the body we are radiographing corresponds to the object. The plate or film corresponds to the screen or surface on which the shadow falls.

Q. What is the ideal relationship between (1) X-ray tube (2) object and (3) plate or film to avoid distortion of the shadow?

A. Have the X-rays strike the part being radiographed and the surface of the film or plate at right angles—i. e., "perpendicular to their surfaces" to use a common phrase.

Q. Describe very briefly the making of a radiograph of the hand up to the point where the film is to be developed.

A. With the plate or film loaded in envelopes or a kassett, place it on a table or stand, or any flat horizontal surface, with the sensitive side up. Place the hand to be radiographed on the loaded plate. Place the X-ray tube directly above hand and plate (or film). While the hand and plate remain perfectly immobile light the X-ray tube for a predetermined length of time, say for example 3 seconds.

The X-rays shine down from the X-ray tube, penetrating the hand in direct proportion to the density. Thus they penetrate the flesh of the hand much more readily than the bones. They penetrate the paper of the envelopes or the material of which the kassett is made as readily as ordinary light penetrates window glass.

Q. Suppose that, by accident, the sensitive side of the plate presented away from the part being radiographed and the X-ray tube, instead of toward the part and tube, would the exposure fail to make a picture?

A. The exposure would make a picture, but it would not be as clear as though the sensitive side had been presented the right way.

Q. Does that part of the plate just under the bones receive more or less X-radiation than other parts of the plate?

A. Less, because the bone offers more resistance to the X-rays than the soft tissues of the hand, and as has been pointed out, the envelopes or kassett offer practically no resistance.

Q. After exposure (of the part being radiographed and the plate or film) to the X-rays, what is the next step in the making of a radiograph?

A. Photographic development.

Q. Does exposure of the plate or film alter its appearance?

A. After exposure, and before development, the plate or film looks exactly as it did before; no visible change has occured.

Q. After exposure, what is done with the plate or film?

A. In the dark room, in the safe light, the plate or film is removed from the envelopes or kassett and immersed in an aqueous solution of chemicals known as the "developer." ("Developer," "fixer" and other photographic chemicals and supplies may be obtained from X-ray supply houses. The operator may make his own developer, and fixer, by selecting, weighing and mixing the necessary chemicals or he may buy

prepared developer, and fixer, in which latter case the chemicals are packed in suitable boxes with printed directions for mixing with the correct amount of water.)

Q. What does the developer do to the plate or film?

A. It blackens the plate in direct proportion to the amount of X-radiation it has received. Thus that part of the plate or film covered only by the envelope or kassett gets blackest, then the flesh of the hand, then the bones. If there has been a ring on the finger, the least X-radiation occurs under the ring. Therefore the shadow of the ring will blacken least, almost not at all.

Q. How long is the plate or film left in the developer?

A. Usually 5 to 7 minutes. Practically never longer than 10 minutes.

Q. What is the correct temperature of the developing solution?

A. 65° to 70°F.

Q. If the time of exposure has been a little longer than necessary how does this affect the time in the developer?

A. Makes it shorter.

Q. If the time of exposure has not been quite long enough how does this affect the time in the developer?

A. Makes it longer.

Q What happens if the plate is left in the developer after development is complete?

A. It gets too black; it is spoiled. (It can be reduced with suitable reducing solution however.)

Q. How may the operator judge when development is complete?

A. When the outline of the image is seen rather clearly on the non-sensitive side, and not much light is transmitted when the negative is held up to the ruby light.

Q. When development is complete what is done with the plate or film next?

A. It is rinsed, by "sloshing" momentarily in water, then immersed in the fixing solution.

Q. What does the fixing solution do to the plate or film?

A. It dissolves out the silver salt, which has not been blackened, from the emulsion, leaving the negative transparent where there has been no

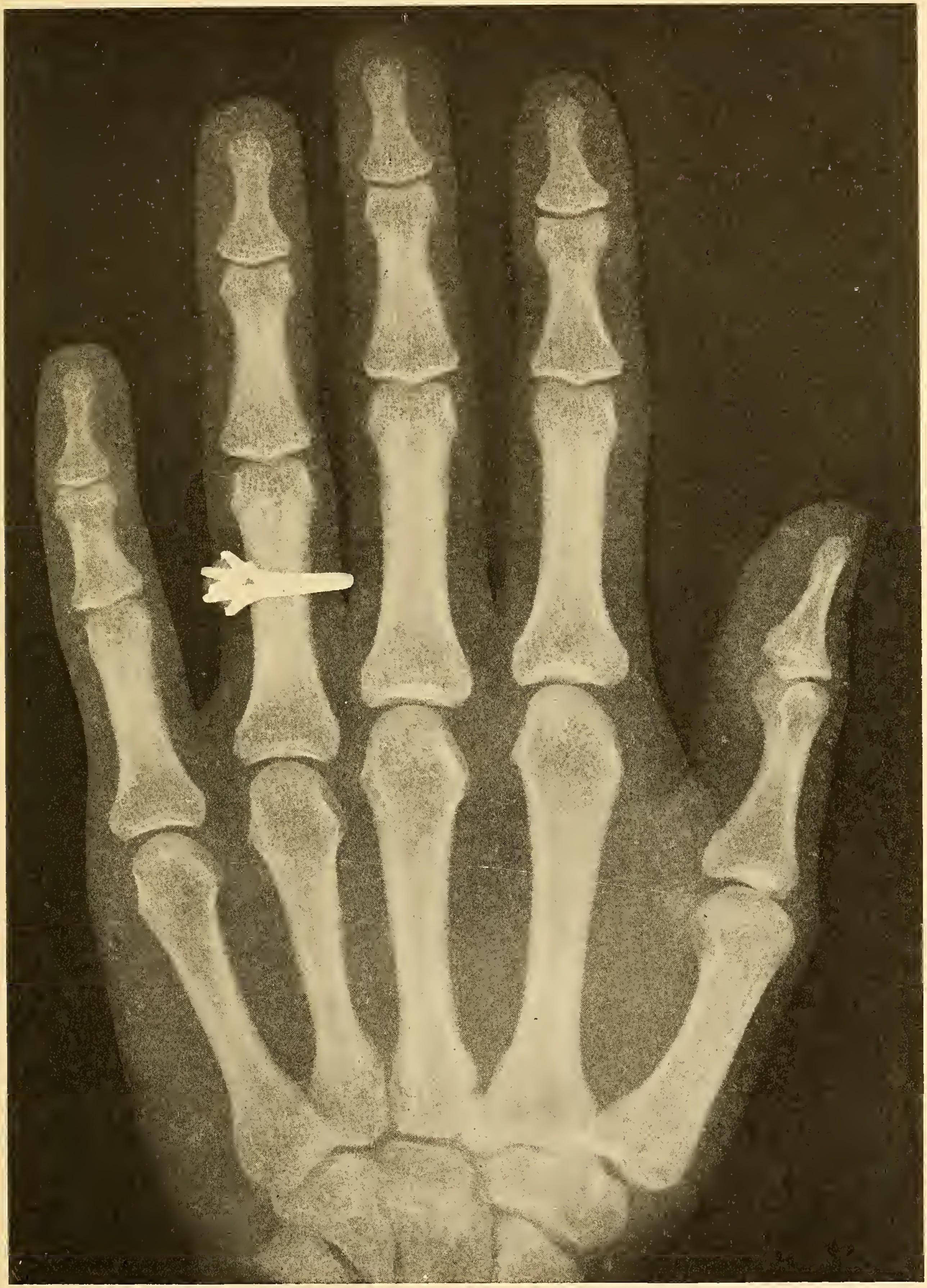


Fig. 5. A radiographic negative of a hand.

Fig. 6. A radiographic print of a hand made from the negative illustrated in Fig. 5.

blackening and varying degrees of translucency according to the degree of blackening by the developer.

Q. How long does it take complete fixing to occur?

A. From about 5 to 15 minutes, depending on the particular plate or film. (Dental films fix in about 3 to 5 minutes.)

Q. How may the operator judge when fixing is complete?

A. Before fixation, the back, or nonsensitive side, of the plate or film has a milky or whitish appearance, due to the presence of the silver salt which has not been blackened. Fixation is practically complete when the whitish appearance disappears. To make sure fixation is complete leave in the fixer a minute or two or three after the negative looks like it is fixed. When fixation is complete the transparencies of the negative show clear when it is held up to the light and observed by transmitted light. Some one has suggested that the negative be left in the fixing solution twice as long as it takes for the milky appearance to disappear from the non-sensitive side. For the sake of safety, this seems to be a good rule, though one which will probably not be carried out to the letter in practice.

Q. The plate must be removed from the developer just as soon as development is complete or the negative will be spoiled. Must it be removed from the fixer just as soon as fixing is complete?

A. No, it need not be. (In hot weather it is not well to leave the negative in the fixer too long, however.)

Q. What is done with the negative after fixing?

A. It is washed in running water for 15 to 30 minutes.

Q. What does washing do to the negative?

A. Washes out all the fixer chemicals.

Q. What happens if the negative is left in the wash water longer than fifteen to thirty minutes?

A. Nothing, if the water is not too warm. If the water is too warm the emulsion is softened and may melt off the celluloid or glass or may show a very finely checkered appearance.

Q. After washing what is done with the negative?

A. It is allowed to dry.

Q. Name the steps in the making of an X-ray negative.

A. (1) Exposure. (2) Development. (3) Fixing. (4) Washing. (5) Drying. It is well to "slosh" the negative in water between the developer and the fixer.

Q. When does the photographic plate or film become a negative and cease to have to be protected from ordinary light?

A. When fixing is complete, or nearly complete.

Q. What is the appearance of a radiographic negative of the hand?

A. The negative can be observed by transmitted light, i. e., by holding it up to some suitable source of light, the sky for example. The bone appears highly translucent or transparent, the flesh of the fingers less translucent, while the balance of the plate is opaque (black). If the hand carried a ring it appears as a transparency.

Q. Why is the picture on the glass or celluloid called a negative?

A. The greater the obstruction to the X-rays at the time of exposure the more transparent the negative in that region. The less the obstruction the darker the negative in that region. In other words the *deeper* the *shadow* cast by the part being radiographed the *lighter* the finished negative in that region. What was transparent to the X-rays appears dark in negatives, what was opaque or semi-opaque appears light. A negative is a diametric opposite to a positive; a positive shadow is dark, but on the film or plate an X-ray shadow is light, hence the name negative applied to the picture on the glass or celluloid.

Q. How may a positive or photographic print be made from a negative?

A. Work in subdued light, say orange light from a dark room lantern. Place the negative in a device known as a printing frame, coated side up. Over this place a piece of photographic paper sensitive side down. Close the printing frame. Now subject the photographic paper to actinic light allowing the light to shine through the negative onto the sensitized paper. In subdued light again remove paper, develop, fix and wash.

Q. What are the blacks and whites of a print compared to those of a negative?

A. Just the opposite. Where the negative was light—i. e. where it allowed the passage of light—the finished print is dark.

Q. When the finished negative is so dark one can scarcely see through it at all what error has been made?

A. The plate has been over-exposed (exposed too long) or over-developed (left in the developer too long) either or both.

Q. How may the mistake of over-exposure be corrected?

A. By leaving the plate in the developer a shorter length of time.

Q. How may the mistake of over-development be corrected?

A. By using a reducing solution. Photographic manufacturing companies and X-ray supply houses make reducing solutions. Two formulas for efficient reducing solutions, and the technic for their use, are given in Chapter XI.

Q. When the finished negative is so transparent that one can scarcely see any image on it, what error has been made?

A. The plate has been under-exposed or under-developed or both.

Q. How may the mistake of under-exposure be corrected?

A. To some extent, by leaving the plate in the developer longer. (No need to leave in the developer longer than about 10 minutes. Leaving the plate in the developer longer will not give a clear image; it will simply darken the whole surface of the negative somewhat.)

Q. How may the mistake of under-development be corrected?

A. To some slight extent by use of intensifying solutions. (Photographic manufacturing companies make intensifiers.)

Q. Where may chemicals to make developing and fixing solutions be obtained?

A. Any photographic supply store, or, better, special X-ray supply houses.

CHAPTER VIII

THE TIME OF EXPOSURE (MATHEMATICS)

Q. How may the time of exposure for any particular radiograph be estimated conveniently, easily, and with moderate accuracy?

A. With the Eastman X-ray Exposure Slide Rule.

Q. Is it the tendency of the Eastman X-ray Exposure Slide Rule to overestimate or underestimate the time of exposure?

A. It is the writer's experience that the tendency is to underestimate the length of time required.

Q. Name some things that influence the time of exposure necessary to make an X-ray picture.

A. (1) Milliamperage. (2) Voltage. (3) Distance. (4) Density. (5) Thickness. (6) The make film or plate.

Q. How does the *time* of exposure influence the X-ray energy delivered to the photographic plate?

A. The X-ray energy delivered to the photographic plate varies in direct proportion to the length of time of exposure. Thus, other factors remaining constant, the X-ray energy delivered to the plate is twice as much from a 4-second exposure as from a 2-second exposure.

Q. How does the milliamperage passing through the X-ray tube influence the amount of X-ray energy delivered to the photographic plate or film?

A. The amount of X-ray energy delivered varies in direct proportion to the number of milliamperes. Thus, other factors remaining constant, the photographic effect on the plate is twice as much from 20 milliamperes as from 10 milliamperes.

Q. Why does the milliamperage through the tube influence the amount of energy (or effect) delivered to the plate or film?

A. Because the higher the milliamperage the *more* X-rays are generated.

Q. When one speaks of *"current"* through the X-ray tube, what is meant by *"current"*?

A. Milliamperage.

Q. How does the milliamperage passing through the tube influence the time of exposure necessary?

A. The time of exposure necessary varies in inverse proportion to the milliamperage.

Q. Apply the rule just given to the following problem: the time of exposure with 10 milliamperes is 10 seconds (to make a certain radiograph). What would the time of exposure be with 20 milliamperes (other exposure-controlling factors remaining the same)?

A. Twenty (milliamperes) is what proportion of 10 milliamperes? It is $^{20}/_{10}$. That is to say 20 is twice ($^{2}/_{1}$) as much as 10. The inverse of $^{2}/_{1}$ is $^{1}/_{2}$. Therefore the time of exposure necessary with 20 milliamperes is $^{1}/_{2}$ as much as with 10 milliamperes.

(The writer realizes that this is a rather labored manner of describing a rather simple thing. The desire is to teach a principle, a method of figuring exposure from the rules which govern it.)

Q. Which exerts the greater photographic effect on the plate or film, 5 milliamperes for 10 seconds or 10 milliamperes for 5 seconds?

A. The photographic influence would be the same. The milliampere-second (ma. s.) exposure would be the same.

Q. How does one obtain the milliampere-second exposure?

A. Multiply the number of milliamperes by the time of exposure expressed in seconds. Thus 5 milliamperes for 10 seconds or 10 milliamperes for 5 seconds, both equal 50 ma. s.

Q. How is the voltage passing through an X-ray tube designated?

A. By the number of volts, or kilowatts (Kv.) or by the spark-gap back-up. (And in the case of gas tubes by the state of vacuum referred to as "hard," "medium," and "soft.")

Q. How does the voltage passing through an X-ray tube influence the amount of X-ray energy delivered to the photographic plate or film?

A. The amount of X-ray energy delivered to the photographic plate varies in direct proportion to the square of the voltage (measured in kilovolts, or volts, not spark-gap inches) across, i. e. through, the tube.

Q. How does voltage influence the time of exposure necessary?

A. Other factors remaining constant, the time of exposure varies in inverse proportion to the square of the voltage (measured in kilovolts.)

Q. Work out the following problem according to the rule just given. The time of exposure with 30 Kv. is 4 seconds, what would the time of exposure be with 60 Kvs. to get the same photographic effect on the plate?

A. The square of 60 is 3600. The square of 30 is 900. Thirty six hundred (3600) is what proportion of 900? It is $^{3600}/_{900}$. That is to say, 3600 is four times ($^4/_1$) as much as 900. The inverse of $^4/_1$ is $^1/_4$. Therefore the time of exposure necessary with 60 Kvs. is $^1/_4$ as much as the time necessary with 30 Kvs.

Q. Why does the voltage influence the amount of X-ray energy delivered to the photographic plate?

A. Primarily because the higher the voltage the more penetrating the X-rays. (Also, though it is the milliamperage which has the main control over the quantity of X-rays produced, nevertheless more rays are produced at higher voltages.)

Q. What range of voltage is used in the practice of radiodontia?

A. For intra-oral dental work about 45,000 to 60,000. For extra-oral dental work about 45,000 to 60,000. For antero-posterior antrum work about 60,000, or slightly more.

Q. How does the distance between the X-ray tube's target and the plate or film influence the amount of X-ray energy delivered to the photographic emulsion of the plate or film?

A. The amount of X-ray energy delivered to the photographic plate varies in inverse proportion to the square of the distance (measured in inches) from the focal spot to the plate.

Q. What is meant by film-target distance?

A. The distance in inches between the film (or plate) and the target.

Q. Are measurements ever taken from the glass of the tube instead of the target?

A. No. Measurements are always made from the target. Otherwise confusion would occur due to the fact that X-ray tubes are of different sizes.

Q. How does the film-target distance influence the time of exposure necessary?

A. Other factors remaining constant, the time of exposure necessary varies in direct proportion to the square of the film-target distance.

Q. Apply the rule just given and work the following problem: the time of exposure with the film-target distance 20 inches is 4 seconds. What would the time of exposure be, to get the same photographic effect, with the film-target distance 10 inches (and other factors remaining constant)?

A. The square of 20 is 400. The square of 10 is 100. One hundred (100) is what proportion of 400? It is $^{100}/_{400}$. That is to say, 100 is one fourth ($^{1}/_{4}$) of 400. The time of exposure necessary varies *directly* (*not* inversely) with the square of the distance. Therefore it will take $^{1}/_{4}$ as much time at 10 inches as at 20. One fourth of 4 seconds is 1 second.

Q. How does the density of the part being radiographed affect the time of exposure necessary?

A. The denser the part, other factors remaining constant, the longer the exposure necessary. This is due to the fact that the denser the part the more difficult it is for the X-rays to penetrate.

Q. How does the density of the part affect the voltage needed?

A. The denser the part, the more voltage needed. Thus for dental work the voltage may be as low as a 3-inch back-up (approximately 45,000 volts) while for sinus work the voltage must not be less than a 5-inch back-up (approximately 60,000 volts).

Q. In view of the fact that increased voltage (i. e. penetration) will reduce the time of exposure, why is it not expedient to increase the penetration considerably over that actually needed to penetrate the parts being radiographed, in order to reduce the time of exposure?

A. X-rays of higher penetration do not have as desirable an effect on photographic plates and films as those of less penetration. Thus it is advisable not to use any higher penetration than necessary; this, in order to produce the best-looking negative. The lower penetrations give good-looking, brilliant, black-and-white negatives. The higher penetrations give grayer, less contrasty negatives. Very high penetration may give brownish, gray, ugly negatives.

Q. Will increasing the time of exposure compensate for any lack of voltage (i. e. penetration)?

A. Theoretically, yes, perhaps. Practically, no. If the voltage is too low and the X-rays are simply not penetrating enough to go through the part no *practical* amount of increase of time of exposure will give a good radiograph. For example a 3-inch back-up (approximately 45,000 volts) is about the minimum penetration for dental work; that is intra-

oral dental work. The minimum for extra-oral dental work is about 4½ inches back-up (approximately 55,000 volts). That is the opinion of this writer based on personal experience. Others claim 45,000 volts gives sufficient penetration for extra-oral work. While it may be possible to make extra-oral radiographs with a penetration of only a 3-inch back-up, especially if intensifying screens are used, a back-up of about 4½ or 5 inches is unquestionably better.

Q. Will increased time of exposure compensate for any lack of milliamperage?

A. For all practical purposes the answer, yes, is acceptable.

Q. Will increase in time of exposure compensate for any increase in film-target distance?

A. For all practical purposes the answer, yes, is acceptable.

Q. An exposure is made with the factors as follows: 2 ma.—60 Kv.—60 inches—8 seconds. Another exposure is made with the factors as follows: 5 ma.—40 Kv.—50 inches—5 seconds. What difference, if any, will there be in the amount of X-ray energy delivered to the photographic plate?

A. Let E represent the energy delivered to the photographic plate and work to the following formula: *

$$E = \frac{\text{Milliamperage} \times (\text{Voltage})^2 \times \text{Time}}{(\text{Distance})^2} = ?$$

$$\text{First exposure} = \frac{2 \times 3600 \times 8}{3600} = 16$$

The energy delivered to the photographic plate in case of the first exposure is represented by the figure 16.

$$\text{Second exposure} = \frac{5 \times 1600 \times 5}{2500} = 16$$

The energy delivered to the photographic plate in the case of the second exposure is represented by the figure 16.

Therefore E, the energy delivered to the photographic plate, is the same for both first and second exposures.

* Formula taken from VICTOR SERVICE SUGGESTIONS.

CHAPTER IX

MANIPULATION OF X-RAY MACHINES

Q. What are the principal operating controls on an interrupterless transformer X-ray machine?

A. (1) Main switch. (2) Rheostat. (3) Auto-transformer. (4) X-ray switch. (5) Parallel spark-gap. (6) Tube-regulating spark-gap. (7) Coolidge filament rheostat, or "controller."

Q. What does the main switch do?

A. Starts the motor.

Q. What does the rehostat and auto-transformer do?

A. Regulates the amount of electrical energy forced through the X-ray tube.

Q. When an X-ray machine is equipped with both a rheostat and auto-transformer how are these controls used?

A. Cut out all of the resistance of the rheostat (i. e., put it on the highest button) and use the auto-transformer for regulating the current when using a Coolidge tube.

Cut out the auto-transformer (i. e., put on the highest button) and use the rheostat to regulate the current when using a gas tube.

Q. For what is the parallel spark-gap used?

A. To measure the resistance of the X-ray tube by seeing how many inches of spark it will back up, thus learning the approximate voltage necessary to impress current through the X-ray tube, and so learning the approximate X-ray penetration.

Q. For what is the tube-regulating spark-gap used?

A. To reduce the vacuum in gas tubes *when necessary*. Also to raise vacuum in the case of hydrogen tubes.

Q. What does the Coolidge filament rheostat do?

A. It controls the heat of the tungsten filament in the Coolidge tube.

Q. How is the milliamperage passing through a Coolidge tube controlled?

A. By the heat of the tungsten filament. When the tungsten filament

or coil is cold no milliamperage at all can be forced through the tube and the hotter the filament the more milliamperage the tube will transmit.

Q. How is the voltage or current pressure through a Coolidge tube controlled?

A. By means of the auto-transformer. The higher the setting of the auto-transformer, the higher the voltage. In the absence of the auto-transformer control the rheostat is used to regulate the voltage through the Coolidge tube; it is not as good a control as the auto-transformer.

Q. How is the voltage passed through a gas tube regulated?

A. By the rheostat and state of vacuum of the tube. Leaving the rheostat on the same button, a difference in the resistance of the X-ray tube will make a difference in the relative voltage and milliamperage sent through the tube. If the tube is of high vacuum the voltage raises and the milliamperage drops. If the tube is of low vacuum the voltage drops and the milliamperage goes up—this with the rheostat on the same button.

Q. What is the chief functioning difference between the rheostat and the auto-transformer?

A. As we have just seen, a difference in the tube's resistance, results in a difference in voltage-milliamperage balance. This occurs hardly at all with the auto-transformer. The auto-transformer furnishes practically the same voltage regardless of tube resistance.

Q. Describe briefly the technic of lighting a gas X-ray tube with an interrupterless transformer.

A. 1. Start the motor. 2. Cut out the auto-transformer, if there is one, by putting it on the highest numeral and put the rheostat on button one or two. 3. Test the current through the tube to see that it is going the right way, watching the milliampere meter to see if it registers. (If the current goes the right way the meter registers. Also if the current is passing in the right direction the tube lights correctly with the line of demarcation between the active and inactive hemisphere.) 4. Advance rheostat until the desired milliamperage is obtained. (Or the current jumps the parallel spark-gap.) 5. Test to see how many inches of parallel spark the tube backs up (if desired) and *reduce the vacuum only* if entirely necessary. (The writer makes it a rule never to reduce vacuum of a gas tube for dental work unless the tube backs up more than 5 inches.) 6. To reduce vacuum, retard the rheostat to a low button and send the current through the regulating chamber and across the tube-regulating spark-gap in short flashes.

Q. Describe briefly the technic for operating a Coolidge tube with an interrupterless transformer.

A. 1. Start the motor. 2. Turn on the filament switch with the Coolidge filament controller on a low button. 2. Cut out the resistance of the rheostat, if the machine has both rheostat and auto-transformer, by setting it on the highest, or next to highest, button and cut in the resistance of the auto-transformer by setting it at button one. 4. Flash the current through the tube to see that it is going in the right direction watching the milliampere meter to see if it registers. (If the meter does not register the current is trying to go through the tube the wrong way or the tungsten filament is not lighted.) 5. Manipulate the filament control and the auto-transformer, testing the parallel spark back-up at intervals until the penetration and milliamperage are what is desired. The operator is then ready to make the exposure.

Manipulation of the filament control and the auto-transformer to get a certain penetration and milliamperage is necessary only once as long as the same tube is used. Thereafter the filament controller may be set to draw the same amperage for the filament, and the auto-transformer set at the same button, and the tube milliamperage and the penetration, i. e. voltage or spark-gap back-up, will be the same; except for changes due to line variations in voltage.

Q. How may changes in milliamperage through the Coolidge X-ray tube, due to line fluctuations be prevented?

A. By means of a device known as a stabilizer. In the absence of a stabilizer, the operator may prevent changes of milliamperage through a Coolidge tube, during radiographic exposure, due to line fluctuations, by keeping his hand on the filament controller and manipulating it as necessary to hold the milliamperage passing through the tube constant.

Q. Give two rules for regulating the penetration and milliamperage of Coolidge tubes.

A. 1. To increase milliamperage through the tube, advance the filament controller.

2. To increase voltage, advance the auto-transformer; or rheostat, if the machine has no auto-transformer control.

Q. Give two exceptions to the two rules just given; when machine has only rheostat control.

A. 1. When advancing the filament current controller does not result in increase of the milliamperage through the tube, *then* advance the rheostat.

2. When advancing the X-ray machine rheostat does not give a spark across the desired spark-gap but does give too much milliamperage through the tube, *then* retard the filament current controller.

Q. What are the principle operating controlls on the Coolidge unit X-ray machines—i. e., Coolidge dental units?

A. (1) Main switch. (2) Filament switch. (3) Current regulator. (4) X-ray switch.

Q. What is the function of the main switch on a Coolidge unit?

A. To bring the current into the X-ray machine.

Q. What is the function of the filament switch on a Coolidge unit?

A. To throw the current into the tungsten filament.

Q. What is the function of the current controller on a Coolidge unit?

A. To control the milliamperage through the tube by controlling the heat of the tungsten filament.

Q. Describe briefly the technic for using the Coolidge unit.

A. First, after the main switch is turned on, turn the current into the filament.

Second, flash the current through the tube by means of the X-ray switch, reading the milliameter.

Third, if the right amount of milliamperage is not passing through the tube, increase it or decrease it by turning the knob, the current regulator.

Q. What makes different settings of the current regulator on Coolidge units necessary?

A. Line variations; that is to say variation or difference in voltage at different times. A new device, the stabilizer, prevents line variation from affecting milliamperage through the tube.

Q. What are the principal operating controls on an induction coil?

A. (1) Main switch. (2) Rheostat. (3) Variable inductance. (4) Interrupter. (5) Parallel spark-gap. (6) Tube regulating spark-gap. (7) Inverse spark-gap.

Q. What is the function of the main switch on an induction coil?

A. To throw the current into and through both machine and X-ray tube

Q. What is the function of the rheostat on an induction coil?

A. To regulate the amount of current entering the machine and so the amount generated and sent through the X-ray tube.

Q. What is the function of the variable inductance control?

A. Only a few of the most elaborate induction coils have this control. It regulates the voltage of the X-ray current.

Q. What is the function of the interrupter control?

A. Regulation of the interrupter regulates, within limits, the output current of the X-ray machine. The interrupter is manipulated to give a fuzzy flame spark, not a thin blue spark, across an air gap at least as wide as the parallel spark-gap back-up of the tube used.

Q. What is the function of the parallel spark-gap?

A. To measure the resistance of X-ray tubes and so learn the voltage necessary to pass current through them. (Also to assist in regulating the interrupter so that the induction coil will give a fat fuzzy spark across the air gap. The fuzzy spark indicates high milliamperage, the thin blue spark low milliamperage or quantity.)

Q. What is the function of the tube-regulating spark-gap?

A. Same as on the interrupterless transformer, i. e., to regulate gas tube vacuum *when necessary*.

Q. What is the function of the inverse spark-gap?

A. To cut inverse current out of a gas tube.

Q. Describe briefly the technic of using a gas tube on an induction coil.

A. (1) With the rheostat on a low button, flash the current through the tube by momentarily closing the main switch. See that the current is passing through the tube in the right direction by seeing the active hemisphere light correctly and seeing the milliampere meter register correctly. (2) Advance the rheostat until the desired milliamperage passes through the tube. (3) If necessary, regulate the vacuum by sending current through the regulating chamber and the tube-regulating gap; this, with the rheostat on a low button. (4) If there is inverse current passing through the tube indicated by light rings in the non-active hemisphere, (a) retard the rheostat and use less current or (b) use less voltage by changing the multiple inductance control or (c) open the inverse spark-gap or (d) interpose valve tubes, in series, between the terminals of the X-ray machine and the X-ray tube.

Q. Is there ever a light ring in the inactive hemisphere which does not indicate inverse current passing through the tube?

A. Some gas tubes with cathode metal collars, (which protect the glass of the tube in the region of the cathode) cast a light ring in the inactive hemisphere of the tube. This ring does not indicate that inverse current is passing through the tube.

Q. What are the principal operating controls of the high-frequency X-ray machine?

A. (1) Main switch. (2) Rheostat. (3) Current regulating spark-gap. (4) Parallel spark-gap.

Q. What is the function of the main switch?

A. To throw the current into and through the X-ray machine and tube.

Q. What is the function of the rheostat?

A. To control the amount of current entering the machine and so the strength of the output X-ray current of the machine.

Q. What is the function of the current regulating spark-gap?

A. A device by means of which the output or X-ray current may be changed in relative voltage and milliamperage.

Q. What is the function of the parallel spark-gap?

A. To measure the back-up of the X-ray tube and to assist when regulating the current by means of the current regulating spark-gap to make it as high in milliamperage as possible and still be of sufficient voltage to jump the parallel spark-gap.

Q. Describe briefly the technic for using a high-frequency machine.

A. (1) Set the parallel spark-gap at about 5 or 6 inches. (High-frequency X-ray machines are small. They seldom have a parallel spark-gap of more than 5 inches.) (2) Put rheostat on last button or near last button. (3) Close the main switch, momentarily, repeating as necessary to test current. (4) Manipulate the current regulating spark-gap until it gives the fattest, fuzziest spark obtainable across the gap. (This indicates the highest milliamperage obtainable). (5) Open main switch. (6) Connect tube. (7) Flash current through tube. (8) Regulate tube vacuum if necessary—i.e. if the tube backs up the current across the parallel spark-gap. (9) To regulate tube move rheostat to low button.

Q. Describe briefly the technic for using the old dental units with the combination gas tubes.

A. These old dental units with the gas tubes were simply induction coils and high-frequency coils with some of the operating controls left off. They were operated, as far as possible in the absence of some of the controls, the same as induction coils and high-frequency coils.

Q. Why were the old gas tube dental units more likely to cause dermatitis than modern units or other types of X-ray machines?

A. The old gas tube *"dental units"* had no parallel spark-gap. Therefore the "back-up" of the tube could not be measured. As a result of this, the X-ray *penetration* could not be estimated. In the absence of a means to measure it, the penetration sometimes would fall to the point where good X-ray negatives could not be made; this, without the operator's knowledge of the fact. The operator would then try to overcome his difficulties by prolonging the exposure. Under such circumstances the exposures were sometimes prolonged to such an extent as to cause dermatitis.

While the Coolidge tube units have no spark-gap for estimating the penetration, there is no danger of a great drop in X-ray penetration with the Coolidge tube.

Q. Can Coolidge tubes be used on induction coils and high-frequency coils?

A. Coolidge tubes may be used on induction coils, but it is impractical to try to use them on high-frequency coils. They are used extensively on induction coils in England and on the Continent, but, in America, they are used almost exclusively on interrupterless transformer machines or Coolidge units.

Q. Describe the technic for using the Coolidge oil-immersed dental unit.

A. Set the time switch. Press the button. There are no other controls.

CHAPTER X

ELEMENTARY DENTAL TECHNIC

Q. What are the requisites of a dental X-ray outfit?

A. (1) X-ray machine. (2) X-ray tube. (3) X-ray tubestand to hold X-ray tube. (The X-ray unit consists of (a) machine (b) tube and (c) stand). (4) Films. (5) X-ray proof box in which to keep supply of films. (6) Filmholder to hold films in the mouth. (7) Angle meter. (8) Vessels to hold developing solution and fixing solution, also wash water. (9) Developer and fixer chemicals. (10) Dark room light or lantern. (11) A graduated measuring glass—i. e. "glass graduate." (3 to 6 oz). (12) Clips to hold films.

Q. What is meant by intra-oral radiography?

A. Dental radiography in which the films are placed in the mouth for exposure.

Q. What is meant by extra-oral radiography?

A. Dental radiography in which the films or plates are placed outside the mouth.

Q. What are the steps in making an intra-oral dental X-ray negative?

A. (1) Pose the patient and position the X-ray tube. (2) Place the film in the mouth. (3) Make the exposure. (4) Develop, fix, wash and dry the negative.

Q. How should the patient be posed for intra-oral X-ray work?

A. The best and the most popular position of the patient for intra-oral dental X-ray work is the upright sitting position. Pose the head so the roots of the teeth being radiographed are substantially vertical. (Use a head rest so the patient can hold the head still). Another way to express this same idea is to say, "have the occlusal plane horizontal" * or still another very simple way to express the idea it to say, have the head *straight up.*

Q. What device may be used to determine the correct position of the head for intra-oral X-ray work?

A. The Simpson Occlusal Plane Finder.

* Simpson.

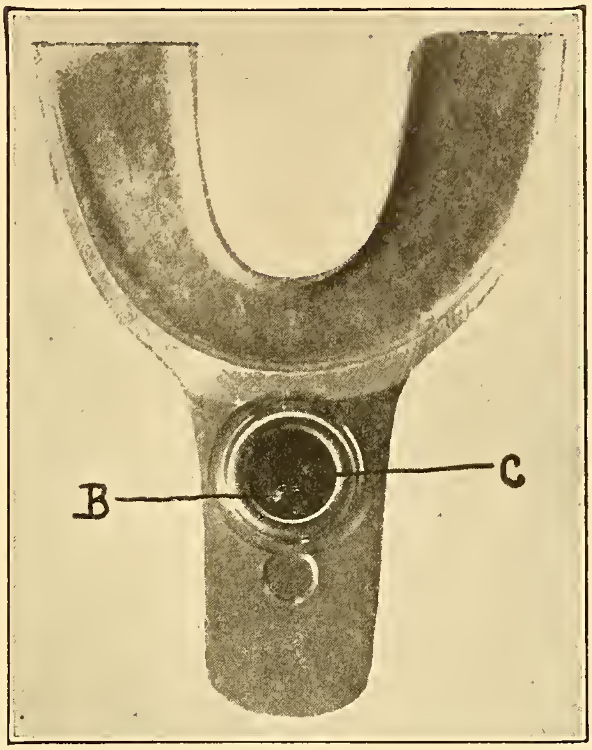


Fig. 7. The Simpson Horizontal Occlusal Plane Finder, a device for determining the correct position of the head for intra-oral X-ray work. C, center of the spirit level. B, bubble.

Fig. 8. The Occlusal Plane Finder in the mouth. The head is moved until the bubble in the spirit level registers center. This instrument is the only device thus far suggested for measuring the position of the patient's head.

Q. Give a simple rule, which is easy to follow in practice, for positioning the head for intra-oral radiodontic work.

A. For the upper teeth, have the head in such position that a line drawn from the tragus to the ala of the nose is horizontal.

For the lower teeth, have the head in such position that a line drawn from the tragus to the corner of the mouth is horizontal.

(These lines may be imagined, or actually drawn on the face. A con-

Fig. 8A. While the Occlusal Plane Finder enables the operator to place the head in such position that the occlusal plane is horizontal, still the Finder cannot be used *while* the films are in the mouth, which is the time the operator wishes to horizontalize the plane. So the *External Occlusal Plane Indicator* may be placed on the side of the head at the temple.

The External Occlusal Plane Indicator is simply a piece of gummed cloth or paper with two lines on it.

First place the Occlusal Plane Finder in the mouth and move the head until the spirit level registers center. Then moisten the External Occlusal Plane Indicator with a drop of water and apply to the temple. The Occlusal Plane Finder may now be removed from the mouth, laid aside, and the operator horizontalizes the upper line for the upper teeth and the lower line for the lower teeth.

The angle at which the lower line, on the External Occlusal Plane Indicator, leaves the upper line is governed by the width to which the mouth is opened. The wider the mouth is opened the more the departure of the occlusal plane of the lower teeth from the occlusal plane of the upper teeth.

When filmholders, like those illustrated in Fig. 21, are used, the mouth is always opened to substantially the same width. Thus the departure of the plane of the lower from the plane of the upper teeth remains practically constant, and so it may be indicated, as it is, by the line on the External Occlusal Plane Indicator. (The reader may observe that holder No. 3 is thicker than holders No. 1 and 2 and would thus hold the mouth open farther. But ordinarily No. 3 is used for the anterior teeth while Nos. 1 and 2 are used for the posterior teeth. It takes a thicker block in the front of the mouth to hold the mouth open to the same width as a thinner one farther back).

(There is another detail that requires further explanation for the more inquiring. The occlusal plane of the teeth in a normal mouth is curved. Obviously a curved line cannot be horizontalized—i. e., made parallel to the floor. It is that part of the occlusal plane from the first molars forward which is horizontalized. The occlusal plane finder is inserted in the mouth only far enough to include the first molars.)

venient and satisfactory manner of drawing them is to cover a string with lip stick or carbon, then apply the string firmly to the face. See Fig. 8B.)

Q. What do these lines on the face represent?

A. The line from the tragus to the ala of the nose represents, in a *moderately* accurate manner, the occlusal plane of the upper teeth.

The line from the tragus to the corner of the mouth represents, in a *moderately* accurate manner, the occlusal plane of the lower teeth. (The wider the mouth is opened, the more the occlusal plane of the lower teeth is changed as compared to the occlusal plane of the upper teeth. When filmholders (Fig. 21) are used the mouth is always opened to a definite distance.)

Q. What mistakes in the position of the head are most likely to occur?

A. When the film packet is placed for the upper teeth, the tendency of the patient is invountarily to move the head away from the film packet as it comes in contact with the tissues. Thus the patient usually tips the head upward and backward too far. *After the film is placed in position, and the patient is holding it by biting on the filmholder, the operator must then see to it that the head is tipped down again to the correct position.*

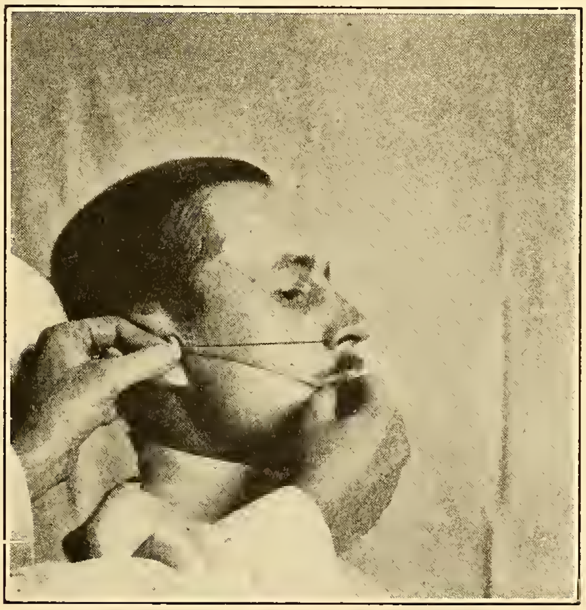


Fig. 8B Facial lines from the tragus to the ala of the nose, and from the tragus to the corner of the mouth indicate respectively the occlusal plane of the upper teeth, and the lower teeth with the mouth open. Simpson suggests that these facial lines are very probably less reliable than the lines of the External Occlusal Plane Indicator correctly applied after using the Occlusal Plane Finder. With this I agree.

The illustration shows the upper line on the face and the operator in the act of printing the lower one by pressing a string coated with lip stick on to the face.

The operator may direct the patient to "put your chin down," at the same time assisting the patient with the hands—Fig. 8D.

It is sometimes necessary to say to the patient, "Don't you try to move

Fig. 8C. When films are placed in the mouth for the upper teeth, the patient practically always tips the head too far back, as illustrated here. The operator must see to it that the head is tipped down again as illustrated in Fig. 8D.

your head at all. Let me move it for you. Don't try to help me." The operator then takes firm hold, one hand on either side of the head and face, and moves the head where he wants it to go.

Fig. 8D See caption for Fig. 8C.

When the film packet is placed for the lower teeth, the tendency of the patient is involuntarily to move away from the film packet as it encroaches on the tissues, thus tipping the head too far downward and forward. *After the film packet is placed in the mouth, and is being held in place, the operator must then see to it that the head is tipped up again to the*

Fig. 8E. When films are placed in the mouth for the lower teeth, the patient practically always puts the chin down too far, *for the correct position for the lower teeth,* as illustrated here. The operator must see to it that the head is tipped back (chin raised) far enough as in Fig. 8F.

Fig. 8F. See caption for Fig. 8E. It is a mildly amusing bit of perversity that the patient involuntarily moves the head to the correct position for the lower teeth when the operator is radiographing the *uppers,* and assumes the correct position for the upper teeth when the operator is radiographing the *lowers.*

correct position. Instruct the patient to "tip your head back" or "raise your chin."

Q. The position of the head is more likely to be wrong for some teeth than for others: which teeth are these?

A. The front teeth, both upper and lower.

Q. When the head is tipped too far back when taking the upper anterior teeth, what is the effect on the roadiograph?

A. The teeth are distorted—i. e., elongated.

Q. When the head is tipped too far down when taking the lower anterior teeth, what is the effect on the radiograph?

A. The operator may fail to get the ends of the roots in his radiograph.

Q. How does the position of the X-ray tube—i. e., the vertico-horizontal angle of the X-rays—affect the X-ray picture?

A. The angle of the X-rays may cause elongation or foreshortening of the radiographic shadow.

Q. Make a drawing showing how the angle of the X-rays may cause elongation or foreshortening.

A. See Fig. 9.

Q. In what two ways may the X-ray angle be varied?

A. Vertico-horizontally (Figs. 11 and 12) and mesio-distally (Fig. 13). A shorter name for the vertico-horizontal angle is the *vertical angle.* A shorter name for the mesio-distal angle is the *horizontal angle.* Variations of the mesio-distal (or horizontal) angle are all presumed to be on the same plane, that is a horizontal plane. Variations of the vertico-horizontal angle are all presumed to be on the same plane, that is a vertical plane.

Q. What is the ideal vertico-horizontal angle and where, in intra-oral radiography may this ideal be attained with moderate consistency?

A. The ideal vertico-horizontal angle is where the X-rays strike (the long axis of) the teeth at right angles, i.e. an angle of 90 degrees, and the plane or surface of the film also at right angles. The ideal angle is most often attainable in the lower molar region.

Q. Why cannot the ideal position of having the X-rays strike the part and the film at right angles be attained in any of the upper teeth?

A. Because of the shape of the palate.

Q. When it is necessary to depart from the ideal just how far is the operator justified in departing?

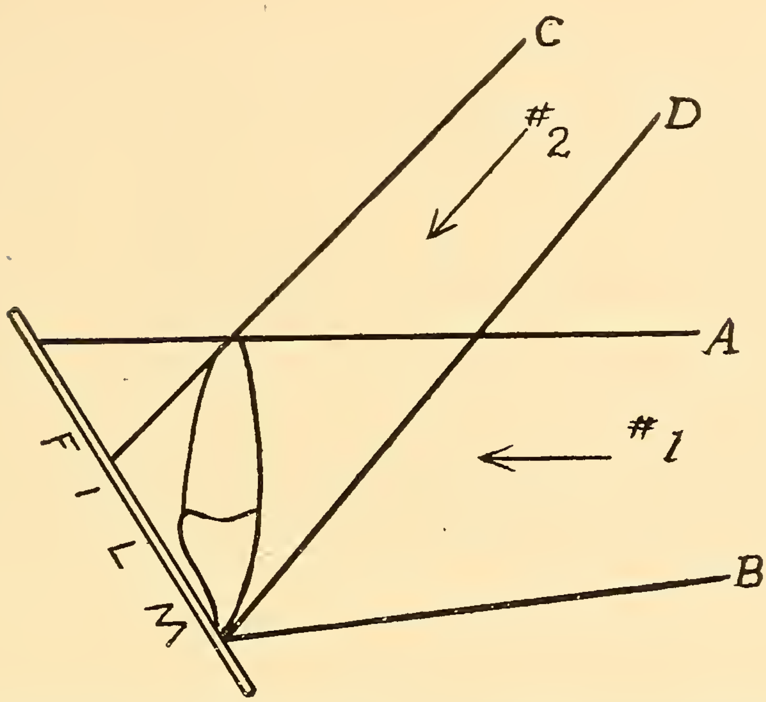


Fig. 9. If the angle of the X-rays is like arrow No. 1 the shadow of the tooth falls on the film between lines A and B causing elongation. If the angle of the X-rays is like arrow No. 2 the shadow of the tooth falls on the film between lines C and D, causing foreshortening. The correct angle to avoid elongation or foreshortening is somewhere between the angles indicated by arrows No. 1 and No. 2.

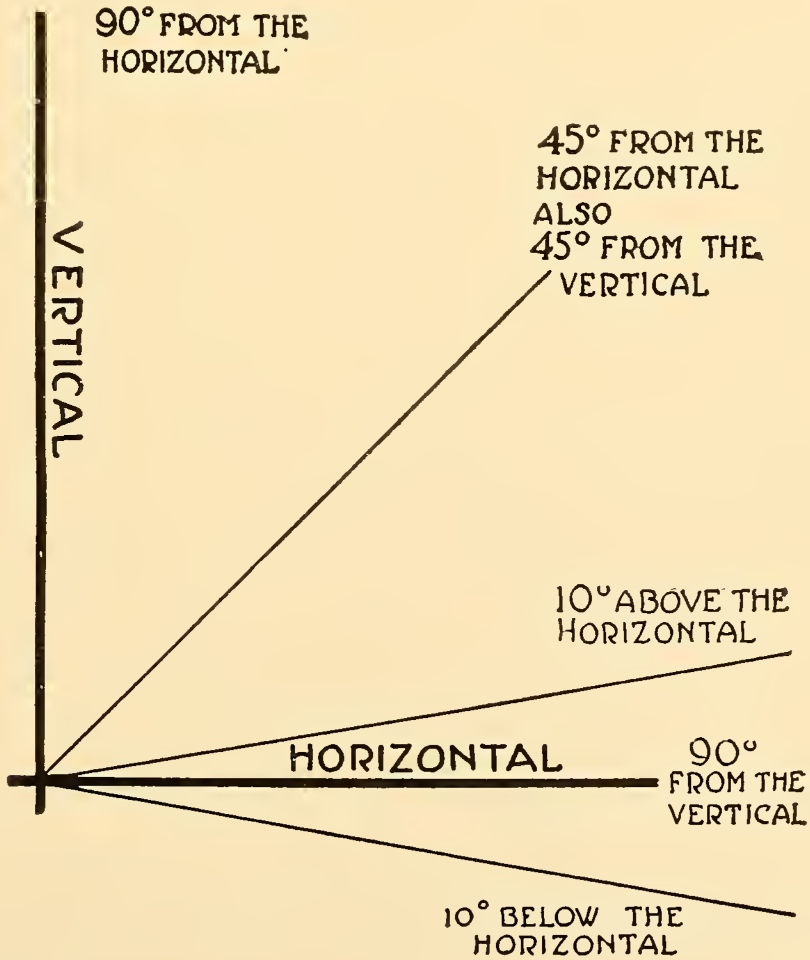
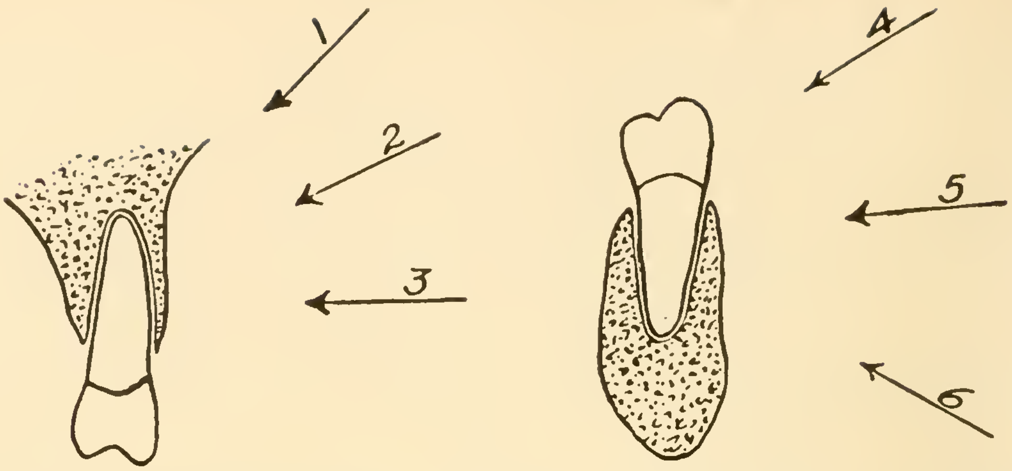


Fig. 10. The use of this illustration is simply to show those who have forgotten what is meant by such phrases as "ten degrees above the horizontal", etc.



Figs. 11 and 12. Sketch of upper and lower tooth in jaw bone with arrows illustrating variations of the *vertico-horizontal angle;* also spoken of as the *"vertical angle."* (These angles are called the *vertico-horizontal angles* because they vary from the horizontal toward the vertical; they are designated as *vertical angles* because they are all in the same plane, i. e., a vertical plane.)

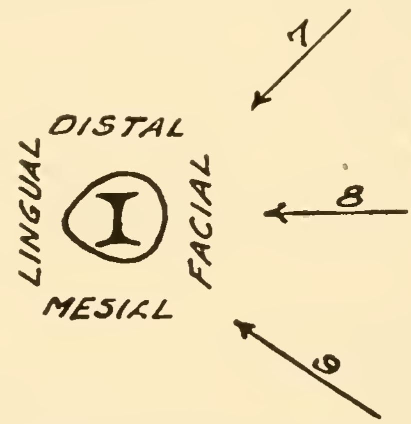


Fig. 13. Sketch of occlusal surface with arrows illustrating variations of the mesio-distal angle; also spoken of as the *"horizontal angle"* because all of the variations of this angle are presumed to be on the same plane, i. e., a horizontal plane.

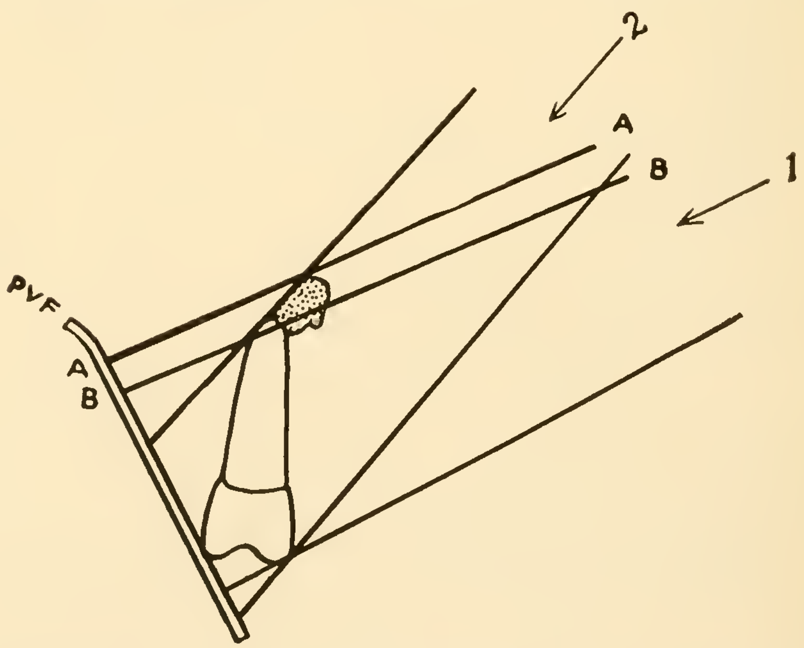


Fig. 14. Illustrating diagrammatically how an abscess at the apex of an upper bicuspid may show or fail to show in a radiograph, depending on the angle. With the angle about 30 degrees above the horizontal, as indicated by the arrow No. 1, the shadow of the abscess falls on the film (PVF) between the lines A and B. With the angle about 50 or 55 degrees above the horizontal, as indicated by the arrow No. 2, no shadow of the abscess falls on the film above the shadow of the end of the root.

A. Only as far as necessary.

Q. Make a drawing showing how a high vertical angle, too far from the ideal, may result in failure to register existing evidence of periapical disease.

A. See Fig. 14.

Q. How may the vertico-horizontal (vertical) angle be determined easily and accurately?

A. By means of a device known as the *Raper angle meter*. (Fig. 16, 17, 18).

Q. Do different teeth require different vertico-horizontal angles? For example is the correct vertico-horizontal angle for upper cuspids the same as for upper molars?

A. Different teeth require different vertico-horizontal angles. The correct average angle for upper cuspids is 45 degrees above the horizontal; the correct average angle for upper molars is 30 degrees above the horizontal.

Q. What is meant by "safe angle," "average angle" and "fine angle" as indicated on the Raper angle meter?

A. The *safe angle* is the vertico-horizontal angle at which there is little or no danger at all (if the film is in the mouth even approximately right) of missing the ends of the roots. The shadows of the teeth are usually somewhat foreshortened by the *safe angle*.

The *average angle* is the vertical horizontal angle at which either foreshortening or elongation of the teeth in the radiograph is least likely to occur. There is more danger of missing the ends of the roots at the *average angle* than at the *safe angle*.

The *fine angle* is an angle to be used in selected cases where anatomical formation permits its use. Unless carefully used the *fine angle* may result in missing the ends of the roots and elongation of radiographic shadows; but foreshortening will substantially never occur at the *fine angle*.

Beginners should start by using the *safe angle;* progress to the use of the *average angle,* thence to the *fine angle* in selected cases, when they have developed skill and judgment.

Q. What is meant by the phrase "thirty degrees above, angle meter"?

A. The phrase "thirty degrees above, angle meter" means thirty degrees above the horizontal and means further that the degrees have

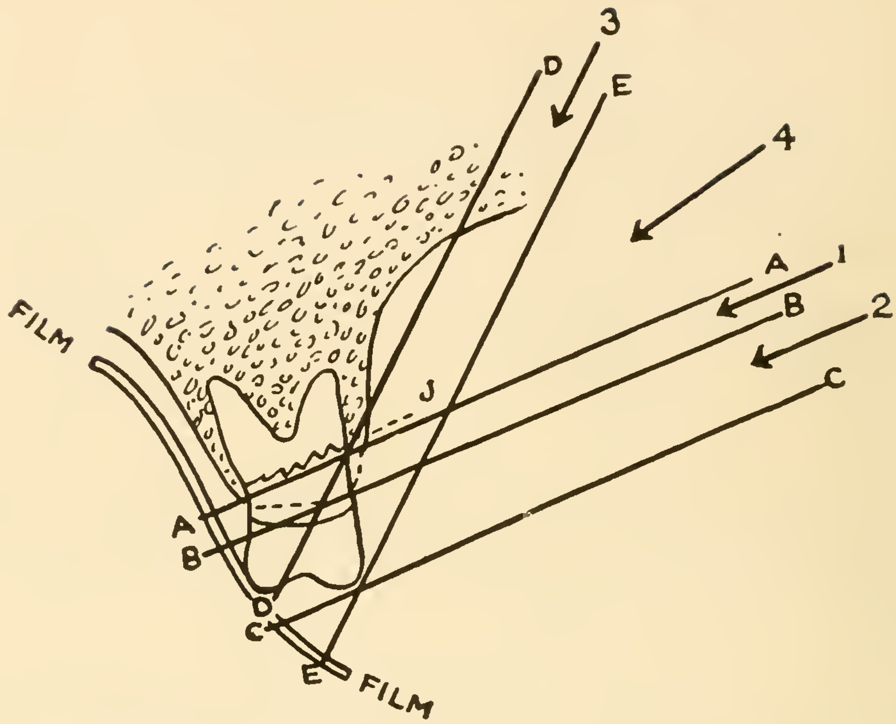


Fig. 15. Diagrammatic illustration showing why loss of bone, due to pyorrhea, may fail to register on the radiograph clearly when the vertico-horizontal angle is too high. The dotted line indicates the bone line in a state of health. The jagged line (J) indicates the bone line produced by pyorrhea—i. e., peridontoclasia. Thus the area included in the dotted and jagged lines indicates the extent of the pyorrhea bone destruction. With the X-rays passing through the parts at an angle of about 20 degrees, indicated by arrows No. 1 and 2, the shadow record of bone destruction falls on the film between lines A and B. The distance between lines A and C is the distance between the pathologic bone line (the jagged line) and the lower border of the crown.

With the rays passing through the parts at an extremely high angle of about 65 degrees, indicated by arrow No. 3, the distance between the pathologic bone line and the lower end of the crown (between lines D and E) is very short, and the shadow record of bone destruction is either partially or completely blotted out by the superimposition of the malar process and other bony tissue. The unskilled observer cannot see the osteoclasia thus obscured by a high angle and the best even the most skillful radiodontist can hope to do is to note its presence—providing a sufficient amount of bone is lost—without, however, getting anything like a clear idea of existing conditions. (In this connection it may be mentioned in passing that while it is true in a general way that peridontoclasia must be on the mesial or distal to be seen radiographically, it is not entirely true. If one will look closely, a line representing the discontinuance of the bone may be seen passing across the roots of the teeth from mesial to distal in pyorrhea cases. This line indicates bone destruction on the facial or lingual, or both).

While the angle indicated by arrow No. 4 would register the evidence of bone destruction on the film quite well, it would not show it as clearly as the angle indicated by arrows No. 1 and No. 2. Slight elongation may be advantageous.

been *measured,* not estimated by eye. A degree on the angle meter is the usual geometric degree. (Fig. 10).

Q. What are some of the advantages of the angle meter over angle determination by eye?

A. Easier. More accurate. Corrections made with certainty. Duplication of angles. Elimination of guesswork. Saves time.

Q. What is meant by "centralize the focal ray"?

A. The *focal ray,* or *central ray* as it is sometimes called, is a more-or-less imaginary X-ray which is presumed to pass from the target of the X-ray tube through the exact center of the X-ray cone or cylinder.

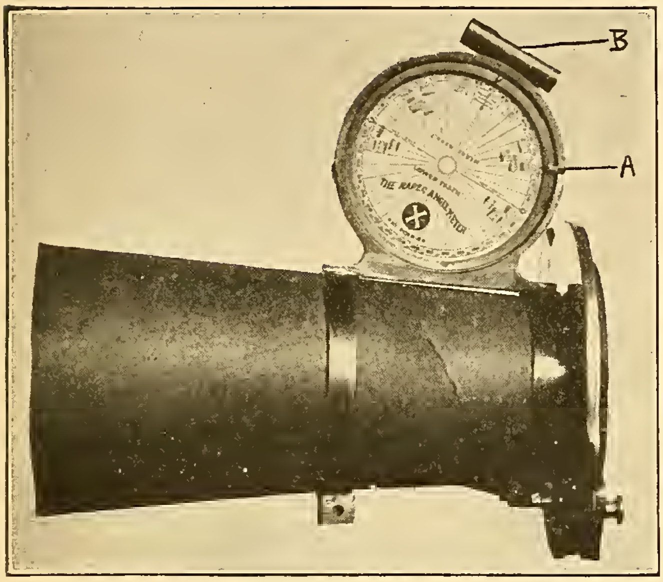


FIG. 16.

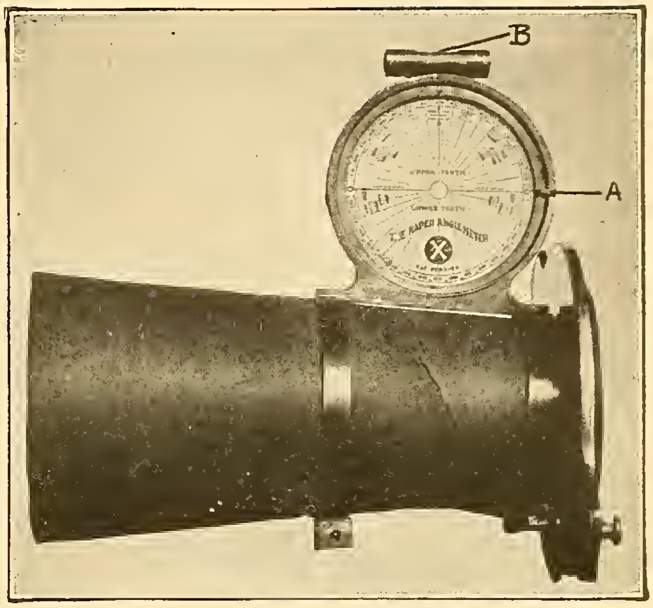


FIG. 17.

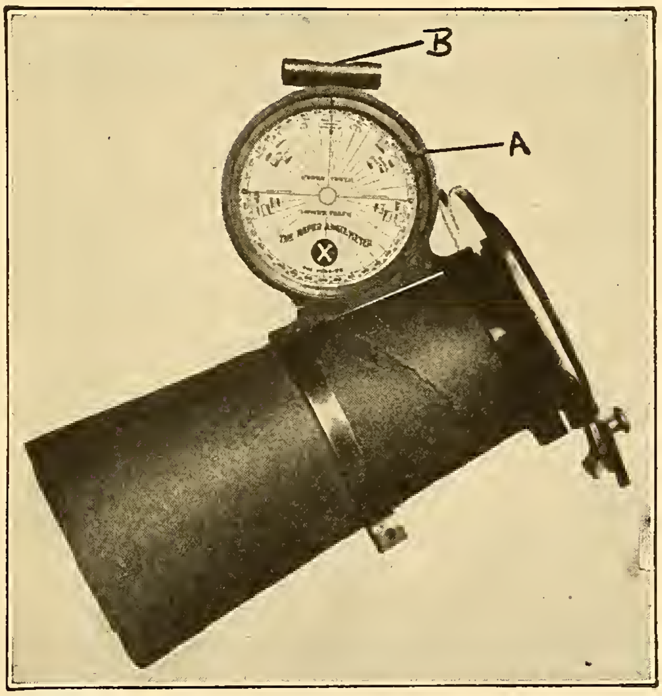


FIG. 18.

Figs. 16, 17 and 18. A crude working model of the Raper *angle meter*. In Fig. 16 the indicator "A" points to zero and the angle of the X-rays is horizontal. In Fig. 17 the dial has been moved to an angle of 30 degrees above the horizontal (an average angle for upper molars); that is to say, the meter is "set" for an angle of "30 degrees above." In Fig. 18 the cone has been tipped until the spirit level, B, registers center; that is, until the cone (and so the X-rays which would pass through it) is tipped at an angle of 30 degrees above the horizontal.

When the cone has been tipped to give the angle for which the angle meter has been set, the operator must make it a point not to change this angle. The focal ray may be centralized by moving the cone, and so the X-ray tube, up or down or sidewise, but the vertico-horizontal angle should not be changed. (The focal ray is a more-or-less imaginery X-ray passing from the center of the focal spot through the center of the cone or cylinder. This ray should also pass through the center of the part being radiographed and strike the center of the film).

Since the meter illustrated here was made, a number of adulterations have been made in the markings on the dial.

Adjusting the X-ray apparatus in such manner that the *focal ray* will pass through the center of the part being radiographed is called "centralizing the focal ray." (See Figs. 19 and 20).

Q. What should the mesio-distal (horizontal) angle be ordinarily?

A. Zero—i. e. straight through the tooth from facial to lingual, not diagonally through. (Fig. 13, arrow 8).

Q. How are dental films supplied for use?

A. In light-proof packets, or "pairs," two films in a packet.

Q. What are the most popular dental films?

A. The Buck X-ograph, and the Eastman, "regular" No. 1, size $1\frac{1}{4} \times 1\frac{5}{8}$ inches.

Q. What is meant by the word "regular" as applied to Eastman dental films?

A. Eastman dental films are either "regular" or "extra fast." The "regular films" are less sensitive than the "extra fast." In brief, the "regular" films are the "slow films."

Q. How much faster is the "extra fast" emulsion than the "regular" emulsion?

A. Other factors remaining constant the exposure for the films with the "extra fast" emulson is only $\frac{1}{4}$ to $\frac{1}{3}$ that necessary for the "regular" films.

Q. What advantage has the "regular" film over the "extra fast" film?

A. Better looking negatives can be made on "regular" films.

Q. What is the most important rule to be observed when placing film packets in the mouth?

A. Bend parts of the packet deliberately, as necessary to conform to the mouth, to allow the packet to go to place readily and *so avoid bending the entire surface of the packet unnecessarily.*

Q. How are film packets held during exposure for the upper teeth?

A. With filmholders, or the patient's fingers or thumb. (The writer prefers a type of filmholder of his own design; one with a flexible back support. Fig. 21).

Figs. 19 and 20. In Fig. 19 the vertico-horizontal (vertical) angle has been set by means of the Raper angle meter, *but the focal ray has not yet been centralized. Without changing the vertico-horizontal angle,* the apparatus is moved and adjusted until the focal ray is centralized as illustrated in Fig. 20. The line C represents the focal or central ray.

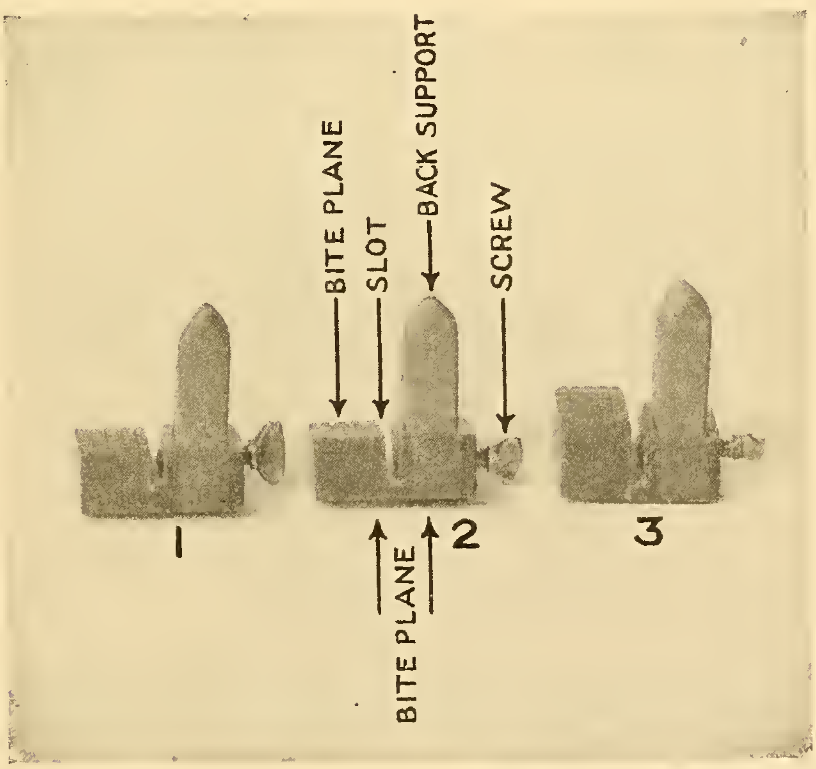


Fig. 21. A set of universal filmholders. More than 98% universal. Flexible back support. Variable slot lengths. Made of radiolucent material.

Q. Give directions for using the thumb to hold films in the mouth.

A. Place packet in mouth and instruct patient to exert pressure of thumb "straight up" for the posterior teeth and "upward and backward" for the front teeth. This pressure, owing to the shape of the palate, (vault of the mouth) will bring the packet into correct contact with the tissues and will keep the packet from slipping downward.

Q. How are film packets for the lower teeth held in position during exposure?

A. With filmholders, or the patient's fingers or thumb.

Q. What three things govern the radiographic image cast on the film and what devices assist in enabling the operator to so arrange these three things to get the best radiographic image?

A. (1) Position of the patient's head—Simpson's Occlusal Plane Finder. (2) Position of the X-ray tube—Raper's Angle Meter. (3) Position of the film in the mouth—Raper's Universal Filmholders. (If the position of the patient's head, X-ray tube and films are taken care of the only remaining variable factor is anatomical variation. Anatomical variation is not as important as is popularly supposed.)

Q. How may the length of exposure be estimated approximately?

A. By means of the Eastman X-ray Exposure Slide Rule.

Q. What is the approximate exposure for intra-oral radiographs with the factors as follows: (1) Film-target distance about 8 inches; (2) Spark-gap back-up, 3 inches; (3) Milliamperes 10?

A. With "extra fast" Eastman dental films, about 2 seconds—i. e. about 20 milliampere seconds (ma. s.). With "regular" Eastman films and X-ograph films, *about* 6 seconds (or 60 ma. s.).

Q. What is the approximate exposure for intra-oral radiographs with the factors as follows: (1) Film-target distance about 16 inches. (2) Spark-gap back-up 5 inches. (3) Milliamperes 20?

A. With "extra fast" Eastman films, about 1 or 2 seconds. With "regular" Eastman films or X-ograph films, about 4 or 5 seconds.

Q. When the time of exposure is 8 or 10 seconds or longer is there any danger of overheating the tube or burning the target?

A. Yes, some, if a fine focus tube is used. The writer avoids this danger by giving *intermittent exposure,* i. e., periods of exposure of about 5 seconds with periods of rest between of 2 to 5 seconds.

Fig. 22. Films held in position with the patient's thumb. (The operator's hand is seen holding the lip back).

Fig. 23. Films held in position with the universal filmholder. The holder and film packet have just been placed in position, and the patient has "closed" on the bite plane of the holder thus holding it and the film in position. (The operator has not yet removed his fingers from the patient's mouth).

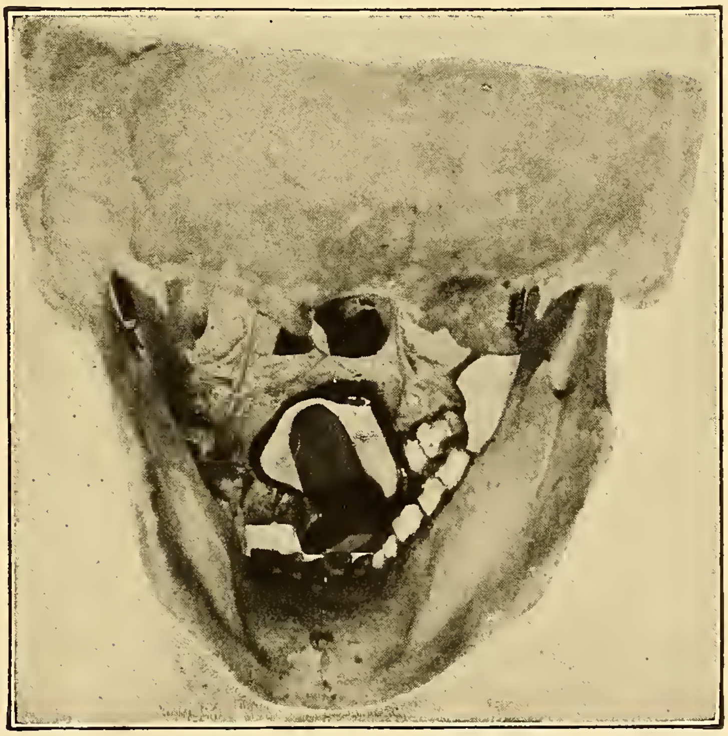


Fig. 24. Lingual view of the film packet held in place by the universal filmholder. Note how the flexible back support bends slightly to conform to the shape of the vault.

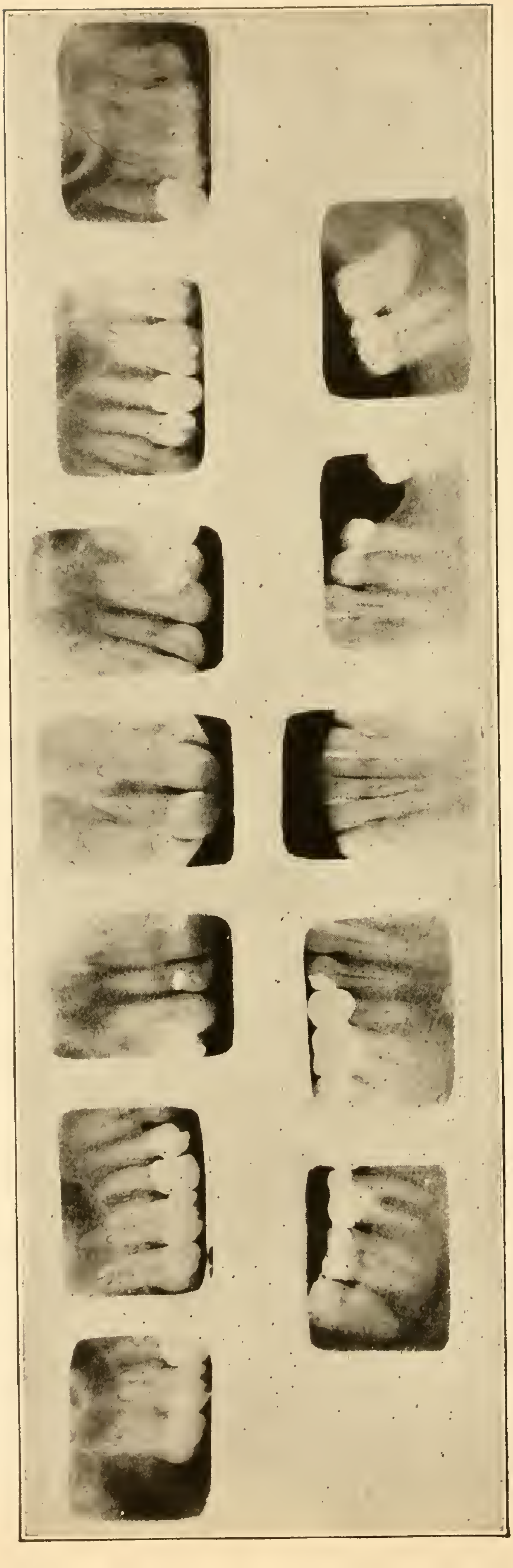


Fig. 25. A 12-film survey of the mouth. All of the films were held in the mouth with universal filmholders. (Fig. 21).
(Figs. 22, 23, 24 and 25 are reproduced by courtesy of C. V. Mosby Co.)

Q. After the operator knows the approximate exposure how may he then learn the exact exposure?

A. By using a standard time developer, i. e. a developer which, at a temperature of 65° F., will develop a correctly exposed plate or film in a certain known length of time. Most developers are 5-minute developers. To learn the correct time for exposure proceed as follows: Make an exposure giving the estimated, approximately correct time. Develop for 5 minutes. If the negatives are too dark reduce the time of exposure thereafter. If not dark enough increase the time of exposure.

Q. Give practical working technic for developing a "pair" of dental films.

A. Even though the operator knows the exact exposure necessary, there is always the chance of variation in some of "the factors," or misjudgment of time. Moderate error in exposure time may be corrected in the dark room.

Place both films of the pair of films in the packet, in the developer, one right after the other. Judge when you think film number one is developed, being sure that it is not over-developed. (Judge development by appearance of image on non-sensitive side or by transmitted light.) Transfer film number one to the fixer leaving number two in the developer. Place the developer vessel in a drawer or otherwise protect it from light, by covering it, for example. After film number one has been in the fixer a minute or two, it is permissible to observe it for a moment by white light. Do so, and the operator will then know whether he should hasten to take film number two out of the developer or leave it for some time. this, depending on the density of negative number one. No need to leave film number two longer than 10 minutes in developer no matter if the first negative is very pale. If the negative is not dark enough in ten minutes, better make another, and longer, exposure.

Q. What is the best position for the patient for extra-oral radiography?

A. It is possible to do extra-oral work with the patient in the sitting position but the writer prefers the reclining, the horizontal position.

Q. What is the difference between what is spoken of as a "lateral head" picture and an extra-oral dental picture?

A. They mean practically the same thing.

Q. What advantage have extra-oral radiographs over intra-oral radiographs?

A. They take in more area and so give the diagnostician a wide view, so revealing things which might otherwise not be seen.

Q. What advantage have intra-oral radiographs over extra-oral radiographs?

A. Intra-oral radiographs are clearer—i. e. show the parts better.

Q. Why are intra-oral radiographs clearer than extra-oral radiographs of the teeth?

A. Because less tissue need be penetrated for intra-oral radiographs.

Q. What penetration is suitable for intra-oral work and exta-oral work respectively?

A. Three to 5 inch back-up for intra-oral work and about 4 or 4½ to 5 for extra-oral work. (If the penetration for extra-oral work is only 3 inches, it is expedient to use intensifying screens.)

Q. Describe the making of an extra-oral radiograph.

A. Load film or plate, size about 5 × 7 in envelopes or kassett. With patient in recumbent position, lay plate on flat surface and let patient lay cheek against plate. Tip tube to about 70° (Angle Meter). Make exposure.

Q. With the position as above described, the teeth of which side are radiographed, the *down-side* resting against the envelope, or the *up-side* toward the tube?

A. The down-side.

Q. Why is the tube tipped?

A. To throw the shadow of the up or tube-side of the jaw upward to keep it from obscuring the radiographic view of the down or plate-side of the jaw.

Q. What may be done instead of tipping the tube to about "70 degrees above" (angle meter)?

A. A wooden "pillow" or "wedge" or incline plane at an angle of about 23 degrees may be used as the surface on which to place the plate and the patient's head.

Q. Leaving the plate and X-ray tube in the same position what effect does turning the head ("moving the nose toward the plate") have on the radiographic image?

A. As the head is turned, the shadow of the up or tube-side of the jaw is cast farther forward and we get a radiographic view showing more of the teeth toward the front of the mouth. Also as the head is turned and we get more teeth toward the front, we bring the shadow of the spinal column over the back teeth. (See Fig. 26).

Q. With the factors as follows what is the time of exposure for an extra-oral radiograph: (1) Film-target distance 20 inches; (2) Spark-gap 5 inches; (3) Milliamperes 20?

A. With average X-ray plate, about 10 seconds. With duplitized film, about 6 or 8 seconds. This time is figured for "head lateral" with the Eastman X-ray Exposure Slide Rule. (The writer would usually make such an exposure intermittently to avoid overheating the tube exposing 4 or 5 seconds, waiting about 3 or 4 seconds, then 4 or 5 seconds more.)

Q. Describe very briefly the position for making an "antero-posterior head" radiograph.

A. Place the plate on a flat horizontal surface. Place the patient's head so the chin, mouth and usually the tip of the nose touches the plate or, to be more exact, the envelope or kassett covering the plate. Direct the X-rays straight downward.

Q. What is the minimum penetration for an antero-posterior radiograph?

A. Five-inch back-up—i. e., about 60,000 volts.

Q. What can one see in an antero-posterior head radiograph?

A. The antra, the frontal sinuses and the ethmoid cells.

Q. How does the exposure time necessary for antero-posterior head radiographs compare to the exposure time for radiographs for other parts of the body?

A. Other facts remaining constant the time of exposure for antero-posterior head radiographs is longer than for any other part of the body.

Q. What may be done to reduce the time of exposure for antero-posterior head radiograph?

A. Intensifying screens may be used.

Q. What is an intensifying screen?

A. An intensifying screen is a piece of cardboard one side of which is coated with a chemical which lights up (i. e. fluoresces or glows) when subjected to the X-rays.

Q. What is the philosophy of the use of the intensifying screen?

A. The coated side of the plate or film and the coated side of the intensifying screen are placed in juxtaposition in the kassett. When the

exposure is made the plate is subjected not only to the X-ray energy but to both the X-light *and* the light from the fluorescence of the intensifying screen.

Q. With the factors as follows what is the exposure for an antero-posterior head radiograph: (1) Film-target distance 22 inches; (2) Spark-gap back-up 5 inches; (3) Milliamperes 20?

A. With average X-ray plate about 20 seconds. With average X-ray plate and intensifying screen, about 8 seconds. With duplitized film, about 15 seconds. With duplitized film and one screen about 7 seconds. With duplitized film and 2 screens, one on each side, about 3 seconds (All the foregoing is figured with the Eastman X-ray Exposure Slide Rule.)

Q. What size plates and films are suitable for antero-posterior radiographs?

A. 6½ x 8½ or 8 x 10.

Q. When a duplitized film is used, what is an easy or convenient way of identifying which side of the film was toward the tube and "part" during exposure?

A. Before the film is loaded, mark with a lead pencil the side which is to present tubeward and patientward.. Mark with a small cross or check mark or number. This mark can be seen on the finished negative. It is unnecessary to mark films or plates with only one side coated, to be able to tell which side presented tubeward, because we always present the sensitive side toward the "part" and the tube.

Q. Describe the Pfahler, intra-oral position for radiographing the sphenoid sinus.

A. Place the films (size about Eastman's No. 2 dental, i. e. 2¼ x 3 inches) flat in the mouth with the sensitive side of the films presenting upward toward the upper teeth and roof of the mouth. Direct the rays downward and diagonally forward through the top of the head. Fast films should be used. Intensifying screens may be used also if desired.*

* The position described here is very similar to the Simpson Localization Position mentioned in Chapter XIII.

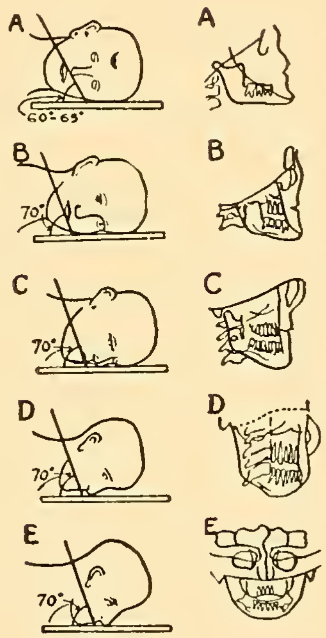


Fig. 26. A study of angles for extra-oral dental radiographs illustrating the effects of rotating the head. (After Cieszynski, and Waite and Bartlett).

The first column shows the position of the head on the photographic plate and the angle of the X-rays.

The second column shows a sketch of the radiographic image cast on the plate by the respective positions illustrated in column one.

Note in the sketch A that the spinal column does not overlap the lower jaw at all. But the jaw of the opposite side is superimposed on the side of the jaw being radiographed until only the third molar region is free from the superimposition.

In B, the spinal column just commences to overlap the ramus. And the shadow of the superimposing jaw of the opposite side is cast forward until it no longer obscures the view as in A.

In C, the head is rotated still farther (nose almost touches the plate) and the resulting radiographic image shows the spinal column lapping the lower jaw obscuring the lower third molar region. The shadow of the superimposing jaw is cast still farther forward and so an unobstructed view is obtained of the teeth farther forward including about the cuspid regions.

In D, the head is rotated still farther and so the shadows of both the spinal column and jaws and teeth of the opposite side are cast still farther forward.

In E, the head is turned until the patient faces the plate directly.

CHAPTER XI

DETAILS IN DENTAL TECHNIC

Q. What are the stock sizes of the Eastman intra-oral dental films?

A. No. 1, $1\frac{1}{4}$ x $1\frac{5}{8}$ inches.
No. 1A, $1\frac{1}{2}$ x $2\frac{1}{4}$ inches.
No. 1B, $1\frac{1}{2}$ x 2 inches.
No. 2, $2\frac{1}{4}$ x 3 inches.

Q. What are the stock sizes of X-ograph or Buck's films?

A. $1\frac{1}{4}$ x $1\frac{5}{8}$ inches, also 1 x $1\frac{1}{4}$ inches.

Q. What may be said about size $1\frac{1}{4}$ x $1\frac{5}{8}$?

A. It is by far the most popular and practical size.

Q. What may be said of Eastman's dental films, sizes $1\frac{1}{2}$ x $2\frac{1}{4}$ and $1\frac{1}{2}$ x 2?

A. The writer finds both of these films too large to go in the mouth like the No. 1 films are used, without considerable bending and discomfort to the patient. They may be used "flat in the mouth"—i. e. horizontally, on a plane with the occlusal plane—having the patient "close" the teeth to hold them. (This is a poor position for a film in the mouth except for localization purposes as mentioned in Chapter XIII).

Q. What is the objection to placing films "flat" or horizontally in the mouth?

A. The added likelihood of distortion of the radiographic image. The horizontal position of the film necessitates a high angle—about 65 degrees above (Angle Meter). Thus there is extreme departure from the rule to have the X-rays directed as near as possible at right angles to the long axis of the teeth. (See Figs. 14 and 15). Both periapical bone destruction (abscess) and cervical bone destruction (peridontoclasia) commonly called pyorrhea, may fail to show in the radiograph or may show indistinctly if the vertical angle is so high.

Q. What is the objection to considerable bending of the surface of the film?

A. Bending of the surface of the film distorts the radiographic image, just as mirrors with bent surfaces distort the reflected image.

Q. What may be said of Eastman's film, size 2¼ x 3?

A. Can be used only extra-orally, or intra-orally held between the teeth.

Q. What is the largest size film which may be placed in adaption to the tissues in the mouth without undue bending?

A. 1¼ × 2 inches. This is an excellent film for the posterior teeth where the desire is to take in as much area as possible without undue distortion or risk of distortion.

Q. What are the Eastman special size small intra-oral dental films, suggested by Brownlie?

A. ¾ x 1⅝ inches and 1 x 1⅝ inches. (The 1 x 1⅝ size may sometimes be used to advantage in children's mouths.)

Q. How may gagging caused by placing the film packet in the mouth be prevented?

A. Having the patient hold the breath. Having the patient allow an anti-emetic (local anesthetic) lozenge to dissolve on the tongue. Spraying the throat with anesthetic solution. Where gagging persists it may be necessary to make an extra-oral radiograph. This costs the patient more and does not give as good a picture. When this information is imparted to the patient it sometimes makes them try harder not to gag. Dr. Mendel Nevin suggests the following prescription:

℞

Procaine powder		24 grains
Supranol (Epinephain)	(cc.)	⅕ grain (1:2000)
Aqua dist. q. s. ad.	(cc.)	mils 30

Sig. Apply to mucous membrane in region of soft palate, pharynx and oral mucosa with cotton which is held by applicator or artery forceps.*

A good anti-emetic tablet is: Novesthene Troches (the Novocol Chemical Mfg. Co., Brooklyn). Allow tablet to dissolve slowly on posterior portion of tongue. There is less gagging when the filmholders illustrated in Fig. 21 are used than when the patient holds the films with the thumb or finger.

Q. What is the usual film-target distance for intra-oral dental work?

A. About 8 inches with the dental units. About 15 to 18 inches with other machines.

* A preparation of this prescription is marketed under the name of Impressionol. It is also used for contraction of the mucosa before taking an impression.

Q. How may the photographic quality of extra-oral negatives be improved by the way they are loaded in the envelopes?

A. Place a piece of polished metal (silver or alloy of tin) of the same size and shape as the plates in with the plates resting in apposition to the non-sensitive surface.

Q. The sensitive side of the film should present toward the teeth and tube during exposure. What happens when it is put in backwards, with the sensitive side of the film away from the teeth and X-ray tube?

A. If the film is backed with metal, development will bring out a radiographic image only very faintly. This, because the metal has prevented exposure of the film.

If the film is not metal backed and the film is placed in the mouth with the sensitive side presenting the wrong way, the resulting radiographic image will not be quite as clear as though the sensitive side had been presented tubeward. When observing such a negative the operator might confuse the right and left sides. Ordinarily when the practitioner observes an intra-oral dental X-ray negative, with the non-emulsion side presenting away from him, it is as though he were observing the parts from inside the mouth—i. e. from the position of the film during exposure. But if the film is put in the mouth wrong (backwards) this is not true.

Q. When a universal fine focus Coolidge tube or a 5-30 radiator Coolidge tube is used, what is the minimum film-target distance and why?

A. These Coolidge tubes are built to take rather large quantities of electrical energy. The focal spots are only as small as is consistent with the tube's capacity. The focal spots, considered from a dental standpoint, are large. If the focal spot is too large the outlines of the radiographic image are not clear. When the focal spot is a little too large this can be compensated for by increasing the film target distance, thus sharpening the outlines of radiographic images. When the universal fine focus Coolidge tube or the 5-30 radiator Coolidge tube is used for intra-oral dental work the minimum film-target distance should be about 15 inches, or preferably more, to avoid blurred outlines.

Q. Give technic for measuring the focal spot.

*A. Make a small pinhole in a sheet of lead about 1/16 inch thick, reaming a little flare at both ends of the hole to remove irregular overhanging margins. Place the lead half way between the target and film

[1] Answered by Dr. C. O. Simpson.

with the pinhole in direct line with the central rays, and the exposure will record the size of the focal point on the film. The distance of the film from the target is immaterial so long as the pinhole is equidistant from them, excepting that a distance of 20 or 24 inches with an exposure of 8 to 15 seconds will better disclose a wavering of the focal spot than a shorter distance and exposure. A wire or screen radiographed from a position halfway between the target and the film will strikingly illustrate the difference in definition obtained with a fine focus and a broader focus tube, but only give relative information about the size of the focal spots. The pinhole method is an adaptation of the pinhole camera, or the camera obscura which was the origin of photography.

Q. When root outlines are blurred in a dental negative what may be the cause?

A. (1) Comparatively large focal spot and short film-target distance. (2) Movement of film, patient or tube during exposure. (3) Incorrect angle. (4) Temperature of developer too high.

Q. What incorrect angle is likely to cause blurring of root outline?

A. When the mesio-distal angle is diagonal—i. e. mesio-lingually or disto-lingually—instead of straight through the tooth from facial to lingual, the root outline may be blurred as a result. This is particularly likely to occur in lower molars, upper bicuspids and lower incisors—i. e. teeth with roots wide facio-lingually and comparatively narrow-mesio-distally.

Q. Why, particularly in cases where the operator wishes to see if there is osteoclasia, due to pyorrhea, is it necessary to have the mesio-distal angle zero—i. e. straight through the teeth from facial to lingual?

A. To see through a paling fence one must look straight through. If one looks diagonally through, the space between the palings appears narrower or the line of vision may even be such as to cause overlapping of the palings. So also if one wishes to see interseptal bone one must look straight through between the teeth.

Q. Is "straight through" the posterior teeth at right angles to the long axis of the tongue?

A. No. Because the rows of teeth diverge posteriorly.

Q. What besides the height of the vault governs the vertical (vertico-horizontal) X-ray angle for upper teeth?

A. Tipping of the teeth facially or lingually. If the crowns of the

CHART OF ANGLES

All of the information given in this chart, except the last column and the footnotes, is conveniently indicated on the Dial of the Raper Angle Meter.

Tooth	*Range*	*Permissible extension of Range*	*Safe Angle*	**AVERAGE ANGLE**	*Fine Angle*	*Remarks*
UPPER TEETH						
Upper Incisors	35–45 Above	——	45 Above	**40 Above**	35 Above	The operator must be careful or he will have the patient's head tipped back too far.
Upper Cuspids	40–50 Above	——	50 Above	**45 Above**	40 Above	——
Upper Bicuspids	25–35 Above	35–40 Above	40 Above	**30 Above**	25 Above	The extended range is practically never needed for the second bicuspid and seldom for the first. When the vault is quite flat and the roots are long, it may be needed to get the root ends of the first bicuspid.
Upper Molars	25–35 Above	25–20 Above	35 Above	**30 Above**	25–20 Above	Use extended range when the vault is very high or the crowns of the teeth are tipped to the lingual.
LOWER TEETH						
Lower Incisors	10–20 Below	——	20 Below	**15 Below**	10 Below	The operator must be careful or he will not have the patient's head tipped back far enough.
Lower Cuspids	15–25 Below	——	25 Below	**20 Below**	15 Below	——
Lower First Bicuspids	10–20 Below	——	20 Below	**15 Below**	10 Below	——
Lower Second Bicuspids	5–15 Below	——	15 Below	**10 Below**	5 Below	——
Lower Molars	0–10 Below	0–5 Above	10 Below	**5 Below**	0–5 Above	Use the extended range when the teeth are tipped to the lingual.
SPECIAL CONSIDERATIONS						
When the crowns of Lower Molars tip far to lingual				**5 Above**		Second and Third Molars are more likely to tip toward the lingual than First Molars.
When the crowns of Upper Molars tip far to the lingual, or the vault is very high				**20 Above**		
When the film is placed flat, i. e., parallel with the occlusal plane (which should be horizontal for the upper teeth)	60–70 Above			**65 Above**		
Extra-oral	65–75 Above			**70 Above**		

When the operator wishes to include two, or more, teeth, calling for different (vertico-horizontal) **ranges**, on the same film, he may select a compromise angle between them, or, better as a rule for routine practice, he may select the **average angle of the tooth calling for the angle farthest removed from the horizontal.** This causes the least amount of foreshortening of the tooth calling for an angle nearest the horizontal, consistent with about a 95+% certainty of getting the apical region of the tooth calling for the angle farthest from the horizontal.

It is sometimes difficult to get a clear outline of the small roots of upper first bicuspids. Deliberate foreshortening by using an angle of 40–45 degrees above will usually "bring out" the roots more clearly. Foreshortening of the roots of any tooth, notably the upper front teeth, **brings** out the root outlines clearer, but does so at a sacrifice of diagnostic quality.

teeth are tipped lingually the vertico-horizontal angle may be lower "as low as 20° (angle meter) or, in rare cases, even lower for upper molars." * (Instead of changing the vertico-horizontal X-ray angle to compensate for tipped teeth it is permissible, if desired, to tip the patient's head to bring the long axis of the teeth to a vertical postion.)

Q. Case: A certain negative, say of the upper anterior teeth or first bicuspid, registers the teeth their approximately correct length but the root outlines are somewhat indistinct, while another negative of the same region which *foreshortens* the teeth shows the root outlines clearly. Why is this?

A. When the angle is such as to cause foreshortening the X-rays pass through the roots (crowns too for that matter) in a diagonal manner. Thus they pass through *more* dental tissue than when the angle is correct to give the right root length, and so of course the shadow of the root is denser and its outline more distinct.

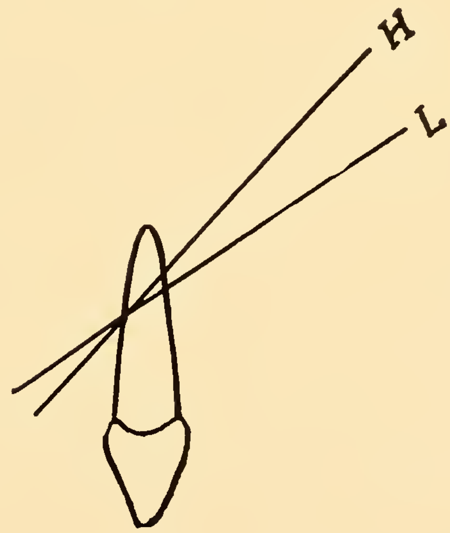


Fig. 26A. Showing that at a high angle (line H) which would cause foreshortening, the X-rays penetrate more dental tissue than at the correct angle (line L) thus causing the outline of the root to be more distinct in the foreshortened negative.

Q. How may the shadow of the malar process and bone be avoided?

A. First, keep the vertical angle as low as possible. Almost never above 30° and as low as 20° (angle meter), depending on the height of the vault and the way the teeth are tipped; that is if tipped at all. Further, a somewhat disto-lingual horizontal angle casts the shadow of the malar process and bone to the distal of the first molar. A somewhat mesio-lingual angle casts the shadow of the malar process and bone to the

*Dr. C. O. Simpson.

mesial of the second and third molars. To get a "somewhat mesio-lingual angle" through the teeth have the horizontal angle substantially at right angles to the long axis of the tongue. (See the chart indicating the horizontal angles for a 14-film survey in Chapter XII.)

Q. What is McCormick's method of avoiding the shadow of the malar bone and process, and how effective is it?

A. McCormick says he avoids casting the shadow of the malar process and bone over the roots of the upper molars by increasing the film-target distance to about 20 or 24 inches.

Kells points out that whether the shadow of the malar process or bone falls over the roots of the upper molar teeth or not depends on the relative position of X-ray tube, film, malar bone and process and roots of the upper molars. If the relative position of these things remain the same the position of the shadow of the malar bone and process and the roots of the molars will be the same, whether the film-target distance is 10 or 20 inches—or 30 or 40 for that matter.

Q. What is the Le Masters' method of avoiding the shadow of malar bone and process, and how effective is it?

A. Le Masters published a very convincing article and diagram showing how the placement of a roll of cotton between the crowns of the upper molars and the film packet, thus making the film more nearly vertical, would result in preventing the shadow of the malar process and bone from falling over the roots of the upper molars.

Simpson reports that he has tried this technic and that it does not "work." Simpson directs attention to the fact that the position of the film is changed in the region of the crown of the teeth by the cotton roll, but it is not changed much, if any, in the apical region. Thus, Simpson argues, the cotton does not change the relationship of film, X-ray tube, and parts being radiographed except in the cervical and coronal region; hence it does not affect the shadow of the malar bone or process at all.

Q. What is the rule commonly given for determining the vertico-horizontal angle of the X-rays and how well may this rule be applied in practice?

A. The rule is "The angle of incident of the normal ray shall strike at right angle the plane which exactly bisects the angle formed between the tooth and film."

In order to apply the foregoing rule the operator must first mentally estimate the long axis of the tooth. Then estimate the plane of the film in the mouth. Then imagine an angle formed by lines representing the

long axis of the tooth and the plane of the film. Then imagine another line which will divide this angle into equal halves. Then estimate the angle of the X-rays to strike this bisecting line at right angles.

It will be seen from the foregoing that the rule given cannot actually be applied in practice unless the operator uses a special computing instrument designed for the purpose. Such instruments have been designed but they have not come into general use. They are not any too convenient to use. This writer prefers not to use such an instrument in routine practice but instead to always have the head and films in the same positions and then to use an angle meter to measure the vertico-horizontal angle of the X-rays. The angle meter is, compared to the other instrument for determining the bisecting plane between the tooth and film, an extremely simple device, and very easy and convenient to use.

Q. Can one get a good radiographic view of all three of the upper molars on a single negative?

A. Usually not. It usually takes at least two negatives, the mesio-distal (horizontal) angle being different to avoid the shadow of the malar process and bone and to see the different roots of these teeth. First make the horizontal angle somewhat disto-lingually and so cast the malar shadow distally, then make the horizontal angle substantially at right angles to the long axis of the tongue and cast the malar shadow mesially, (See the chart indicating the horizontal angles for a 14-film survey in Chapter XII.)

Q. Can the upper cuspid and bicuspids be radiographed on the same negative?

A. Yes, but in order to get the end of the root of the cuspid it is often necessary to use a vertico-horizontal angle that is higher than it should be for the bicuspids. (See Figs. 14, 45, 46 and 47.)

Q. How many teeth go on one intra-oral film?

A. As a rule about three approximating teeth may be radiographed on one intra-oral negative, without undue distortion or blurring. Some exceptions to this rule are: (1) The upper anterior teeth where, usually, but two teeth go on one negative without distortion. (2) The lower incisors where, if there is no irregularity, four teeth go on the negative. (3) The combination of lateral incisor, cuspid and first bicuspid—whether upper or lower—will not go on one negative without foreshortening and the consequent danger of overlooking infection. (4) Irregular teeth. For example, in case of a V-shaped arch it is sometimes impossible to get a good radiographic view of the two central incisors on one negative; it takes two negatives.

(By using a high vertico-horizontal angle and a large film placed horizontally or semi-horizontally in the mouth, as many as six, or even eight, teeth can be gotten on one negative, but there is great likelihood of distortion and the necessary high angle may fail to register existing evidence of infection. Therefore such negatives should be made only in carefully selected cases—where the examination is for supernumerary teeth and odontomata for example.)

Q. What is meant by contrast in a radiographic negative?

A. Contrast means great, or sharp, or very noticeable difference between the blacks and whites of the negative, i. e. the black distinctly black and the white distinctly white (or rather *transparent*, to be more exact).

Q. What is meant by definition in a radiographic negative?

A. Distinctness of outline of the radiographic image as distinct from a hazy or less definite outline.

Q. What is meant by detail in a radiographic negative?

A. Small structures and fine gradations of light and shadow. When there is a great deal of contrast in a photograph or radiograph there is some loss of detail. The ideal radiograph carries as much contrast as possible without loss of necessary detail.

Q. What difference if any is there in a dental radiograph made with a tube with a 3-inch back-up and one with a 5-inch back-up?

A. The contrast (detail too) is better with the 3-inch back-up; the blacks are blacker and the whites whiter.

Q. Why are dental negatives made with a penetration of a 3-inch back-up (45,000 volts) better looking than negatives made with a penetration of a 5-inch back-up (60,000 volts)?

A. Because, within limits, the X-rays of lower penetration have a more desirable effect on the photographic plate. Also X-rays of very high penetration go through even the denser tissues very readily—thus there is not as much contrast, between various tissues, or detail, when the penetration is needlessly high.

Q. What general rule can we formulate from the fact that the X-rays of lower penetration have a more desirable effect on the photographic plate?

A. In radiographic work do not use a great deal more penetration than necessary to go through the part being radiographed.

Q. If a 3-inch gap makes the best looking dental negatives why ever use more penetration?

A. Recall that the time of exposure necessary varies directly in proportion to the square of the voltage. Thus the exposure necessary when the penetration is a 3-inch back-up is much longer than when the penetration is 4½ or 5 inches back-up. (Unless the film-target distance is reduced or the milliamperage increased). Thus it may be expedient to make dental radiographs at a penetration of 4½ or 5-inch back-up to keep the time of exposure down. Very excellent dental radiographs can be made at a penetration of 4½-inch back-up.

Q. What is the usual film-target distance used for intra-oral radiographic work?

A. From about 8 to 18 inches.

Q. How does age influence the length of exposure necessary?

A. Somewhat less in the young.

Q. How does weight influence the length of exposure necessary?

A. Longer exposure for heavy people, because there is more tissue to penetrate.

Q. Is there any variation in the exposure time for the various teeth?

A. About 1/8 to 1/6 more for upper central incisors. About 2/8 to 2/6 more for upper molars, particularly the 2nd and 3rd.

Q. How may exposure time be measured?

A. By watch, stop watch, counting by the operator or time switch. Obviously, the time switch is the most accurate.

Q. How may films be marked for identification?

A. Number patients consecutively. Then mark the number on the sensitive side of the film, before development, by the light of the dark room lantern. Use a lead pencil. Make the figures small and in the corner of the film. Such a mark can be seen on the negative after development.

Q. What sort of vessels may be used for the developer and fixer?

A. Trays or tanks for extra-oral negatives. Trays, tanks, or bowl-like vessels for intra-oral.

Q. When trays are used describe a convenient way of picking small dental films from the bottom of the tray.

A. A small piece of celluloid held in a metal clip or "card holder." "Scoot" the celluloid under the film and lift it up.

Q. When bowl-like vessels are used how are the films handled?

A. Fasten the films on clips ("card holders"); the other end of the clip is hooked over the side of the vessel, allowing the film to hang immersed in the developer, fixer or water as the case may be. (Any container which receives the film or negative in a vertical position may be considered a tank or distinct from a tray which receives the film, plate, or negative in a horizontal position.)

Q. When a large plate or film is placed in a tray full of developer what precaution should be observed, which side should be up?

A. Cover the *whole surface* of the plate or film *promptly*. Do not allow the developing solution to cover only part of the plate or film and remain so for a while. Rocking the tray will expedite covering the plate or film. Rocking the tray also hastens development and makes it more uniform. It moves any particles in the developer that might otherwise rest on the sensitive surface and leave a spot. In the case of the film, the operator will have to watch and push it down when it comes above the surface. Have the sensitive side up.

Q. In the case of duplitized films, sensitive on both sides, which side should go up in the tray?

A. Either side. Rock the tray, so the film will not by any chance lay on the bottom. Push back down when it comes to the top. "Tanks" in which the films may be hung in a vertical position are particularly suited to development of duplitized films.

Q. What happens when the developer is considerably too warm?

A. The detail in the image is spoiled; the negative has a foggy appearance. The gelatinous emulsion swells up and gets soft. It is then easily scarred and scratched and the finished negative may show a finely checkered appearance. If the developer is warm enough the emulsion will actually melt. When the emulsion melts and gets ragged at the edge of the negative, this is called "frilling."

Q. What happens when the developer is too cold?

A. The ideal temperature for the developer is about 65° F. If the temperature is much below 65° the chemical process of development is retarded. Thus a developer which should develop a plate in 5 minutes may take 6 or 8 if it is below 65°.

If the developer is a *little* too warm, the chemical process of development is hastened. Thus a developer which should develop a correctly exposed plate ("correctly timed" is the phrase usually applied) in 5 minutes may develop it in 3 or 4 minutes.

Q. What should the temperature of the fixer and wash water be?

A. At least as low as that of the developer.

Q. How may the temperature of the developer and fixer be kept low enough in hot weather?

A. Keep it in an ice box when not in use. When in use, put trays or tank in larger tray or tank containing cracked ice and ice water.

Q. How may the wash water be kept cool enough in hot weather?

A. Run through an iced coil.

Q. Give a method for hardening the emulsion so it will not run or check in hot weather.

A. When the negative is fully developed, remove from the developing solution and "slosh" it about in water to remove the developer and so stop its action. Put in an alum solution (Chrome alum 1 oz. to water 24 oz.) * for 30 seconds. "Slosh" in water again and then put in the fixer and proceed as usual with fixing and washing.

If desired the films may be hardened first, then rinsed by "sloshing" in water, then developed.

Q. How may the approximate time in developer, fixer and wash water be remembered easily?

A. Remember this: 5, 10, 15 or 20. That is 5 minutes in the developer, 10 minutes in the fixer and 15 or 20 minutes in the wash water. (Ten minutes in the fixer is longer than actually necessary for intra-oral dental films. Extra-oral plates and films often require 10 minutes or longer in the fixer. This, not because they are extra-oral radiographs, but because they are different kinds of films and plates than those ordinarily used for intra-oral work. The films ordinarily used for intra-oral work fix in about 3 minutes).

Q. What causes the finished negative to be stained brown?

A. The most common causes are: Old developer or insufficient washing. A very high X-ray penetration will give the negative a brown ("burned") appearance.

Q. When the finished negative has a finely checkered appearance what has caused it?

A. Usually the negative has been left too long in wash water that was too warm. Do not wash overlong in hot weather.

* Formula by Simpson.

Q. How can the operator tell when developer is too old?

A. The time it takes it to act gets much longer. When the film is left a long time in old developer to accomplish development the negative may come out of the developer stained a brownish color.

Q. How can the operator tell when the fixer is too old?

A. It will not dissolve the white out of the negative.

Q. Give the technic for reducing a negative which is too dark.

A. "Stock solution A, 80 grains of Potassium Ferricyanide to the ounce of water. Stock solution B, one ounce of Hyposulphite of Soda (Hypo) to 8 ounces of water. Keep the ferricyanide solution in amber bottle. Add 80 minims of solution A to an ounce of solution B, for a reducing solution. Dry negatives should be soaked in water for ten minutes before reducing. Dip negative in reducing solution, or apply reducer with camel's hair brush or cotton for local reduction, and immediately wash in water. Repeat until desired shade is obtained, then wash negatives the same as after fixing, to remove the hypo. An experienced worker may use a stronger reducing solution, but this is not to be recommended as strong solutions or delay in washing it off causes discoloration. Personally I have always mixed the solutions by guess and judged by the shade, but I have tested this formula and made it easy to remember—80 grains to the ounce, and 80 mm. to the ounce. The solutions suggested in photographic manuals are usually not strong enough and require too long a time. The reduction may be done in bright light, but the reducing solution decomposes and changes to blue after prolonged exposure to light or air." *

Q. What is meant by "regional reduction" of an X-ray negative?

A. Just the dark part of the negative is reduced by applying the reducer to that part with a camel's hair brush or pledget of cotton.

For this purpose the reducer must not be too strong or it will leave lines of demarcation on the negative showing where the reducer was applied and where it was not.

Q. What regions of what negatives are likely to require regional reduction?

A. (1) Anterior negatives—particularly the upper—in the coronal incisal region. (2) Upper bicuspid and first molar negatives, in the apical region of the biscuspids. (3) Lower molar negatives, in the apical region and below the second and third molars.

* Answered by Dr. C. O. Simpson.

Q. Give a formula for potassium permanganate reducer and the technic for its use.

A. Formula: Potassium permanganate, one dram. One half fluid ounce of sulphuric acid (C.P.) and sixteen fluid ounces of water. Dissolve potassium permanganate in water, then add sulphuric acid.

Comments: The work of reducing can be done in any desired light.

It is best, though not entirely necessary, to soak old negatives in water to soften the emulsion before reducing.

It is best to wash fresh negatives as usual, to free them of "hypo," before reducing. However thorough "sloshing" of the negative in water for a few moments may suffice.

Hold dental negative by means of suitable clip.

Technic: Dip negative in reducing solution and remove immediately and "slosh" in clear water, and then view by transmitted light to see if it is reduced enough. Repeat as often as necessary to obtain desired reduction.

The reducer usually stains the negative. After sufficient reduction is obtained, immerse the negative in the ordinary "hypo" solution (or the hyposulphite solution minus the hardener and "acidifier") until stain is removed. The removal of the stain requires only a few moments.

After stain is removed wash negatives in water as usual.

If the reducer works too fast, dilute with water.

This reducing solution may be used repeatedly.

Q. How may the temperature of the developer, fixer and wash water be tested?

A. With thermometers made for the purpose.

Q. If the air of the dark room is too hot and still what happens?

A. There is the tendency of the wet emulsion of the plates left to dry in hot, still air to melt or get full of little check marks.

Q. How may drying be hastened?

A. By using an electric fan.

Q. When, after washing, there are little particles of fixing salts on the emulsion surface of the negative how may these particles be removed without scratching the emulsion?

A. Wipe gently with a piece of wet cotton.

Q. What is meant by "the hypo"?

A. The fixer, or to be more exact, the fixing solution. Called "hypo" because it contains the salt hyposulphite of soda.

Q. What happens when some of the "hypo" gets in the developer?

A. Developer is spoiled by getting hypo in it.

Q. Give formula for a fast developer.

A.

Solution A

Potassium Hydroxid	oz.	8
Sodium Sulphite (Dry)	oz.	8
Water	fl. oz.	50

Solution B

Hydrochinon	grs.	100
Water	fl. oz.	4

To use: Take the desired amount of stock solution A, say 4 ounces for example, and to it add an equal amount of solution B, making the hydrochinon solution fresh just before mixing with the Solution A.*

WARNING: Solution A is so strongly akaline it is escharotic in its action on the skin.

Q. What is an "acid stop bath" and give a formula for one.

A. An acid stop bath is a bath in which a photographic negative may be immersed to stop the action of the developer. The following is a formula for an acid stop bath:

Acetic acid (U.S.P.)	fl. oz.	1
Water	fl. oz.	6

Q. Give technic for using fast developer, the formula for which is given above.

A. Thirty to sixty seconds in the developing solution. Transfer to stop bath for 5 or 10 seconds. Then in the fixing solution. If desired the operator may "slosh" the negative in water between developer and stop bath, also between stop bath and fixing solution.

WARNING: This developer is so strongly akaline it is escharotic in its action on the skin. If the operator gets any on the hands he should dip the hands *at once* in an acetic acid bath like the stop bath or like the bath recommended in Chapter XIV, for so-called metol poisoning. Always have an acetic acid bath ready for immediate use as an antidote for the hands when using the developer. The writer keeps the bath ready

* This formula is not original with the writer. It was obtained through Doctors Ottolengui and Simpson.

in a finger bowl and immerses the fingers every once in a while as a precautionary measure. Rubber gloves may be used but they are a nuisance.

The hands or fingers should never be immersed in this developer. Thus it cannot be used in the manner ordinary developer is used for tray developing. The writer uses the developer only for the intra-oral dental films. The developer is used in a bowl-like vessel. The films hang into the vessel on a clip or holder which hooks over the side of the vessel. When unwrapped, the films are fastened on clips and thenceforth they are handled by the clips until the negative is finished.

Q. What is the factorial method of development?

A. Different developing solutions have different "factorial numbers." The average is about 20.

Note how long it takes from the immersion of the plate or film in the developer until "high lights" appear—i. e. until the *"first faint trace"* of the image is discernible.

Mutiply this time by the factorial number to ascertain how long to leave the plate or film in the developer.

Suppose it takes 15 seconds. 20 x 15 = 300 seconds, or 5 minutes. The total time in the developer then should be five minutes.

Q. What particular care should be exercised when developing by the factorial method?

A. (1) The developer should be the correct temperature. (2) The developer should be fresh. (As developer gets old its action gets slower.) (3) The developer strength—that is the formula—should always be exactly the same. (4) The darkroom light should always be the same and in the same place, as difference in degree of light would influence the opinion of the operator as to just when the *"first faint trace"* of the image appeared.

Q. How are films and plates which are kept in the same room (or even an adjoining room) with an X-ray tube protected against the action of the X-rays?

A. Keep them in a safe box—i. e. a metal, usually lead, box.

CHAPTER XII

WHOLE MOUTH EXAMINATIONS

Q. How many $1\frac{1}{4}$ by $1\frac{5}{8}$ films does it take to make radiographs of all parts of the mouth?

A. From about 10 to 16.

Q. How are the teeth arranged on the films for a 10-film examination?

A. Five negatives for the upper, 5 for the lower as follows: Negative No. 1 upper left molar region, No. 2 upper left bicuspid, cuspid and lateral region, No. 3 upper incisor region, No. 4 upper right lateral incisor. cuspid and bicuspid region, No. 5 upper right molar region, No. 6 lower left molar region, No. 7 lower left bicuspid and cuspid region, No. 8 lower incisor region, No. 9 lower right cuspid and bicuspid region, No. 10 lower right molar region.

Q. What are the disadvantages and limitations of the 10-film whole mouth examination?

A. (1) One does not always get a good radiographic view of all of the upper incisors. (2) When the upper bicuspids and cuspid are placed on one negative the vertico-horizontal angle necessary to get the end of the cuspid root is so high that we do not get the best radiographic view of the bicuspids. (3) The malar bone sometimes obscures the roots of one or more of the upper molars. (4) It is not always possible to get a good radiographic view of all of the lower teeth on 5 negatives.

Q. How do the teeth go on the negatives for 11-film whole mouth examinations?

A. The same as for a 10-film whole mouth examination except that 2 negatives are used to get the upper incisors instead of 1, and so we do not include the upper lateral incisor on the same negative with the cuspid and bicuspids.

Q. What are the limitations and shortcomings of the 11-film whole mouth examination?

A. The same as the 10-film examination except that we are certain not to miss one of the upper incisors.

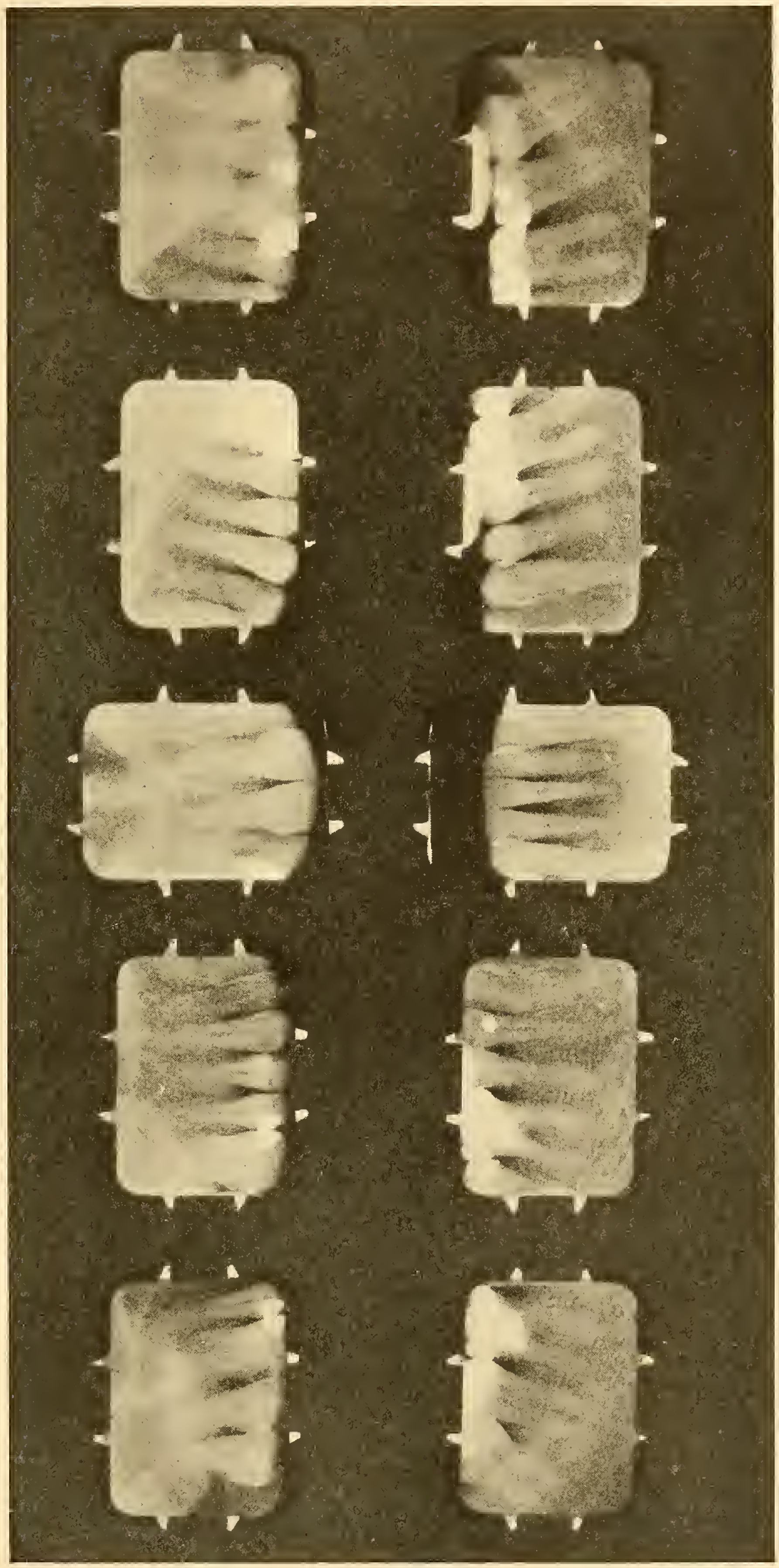


Fig. 27. Ten-film examination (or survey) of the mouth. This survey is widely used in spite of the fact that it has serious faults and shortcomings. In this case the shadow of the malar bone and process overlap the upper molars badly and the lower cuspid and upper lateral regions are not very good though up to the average of the 10-film survey.

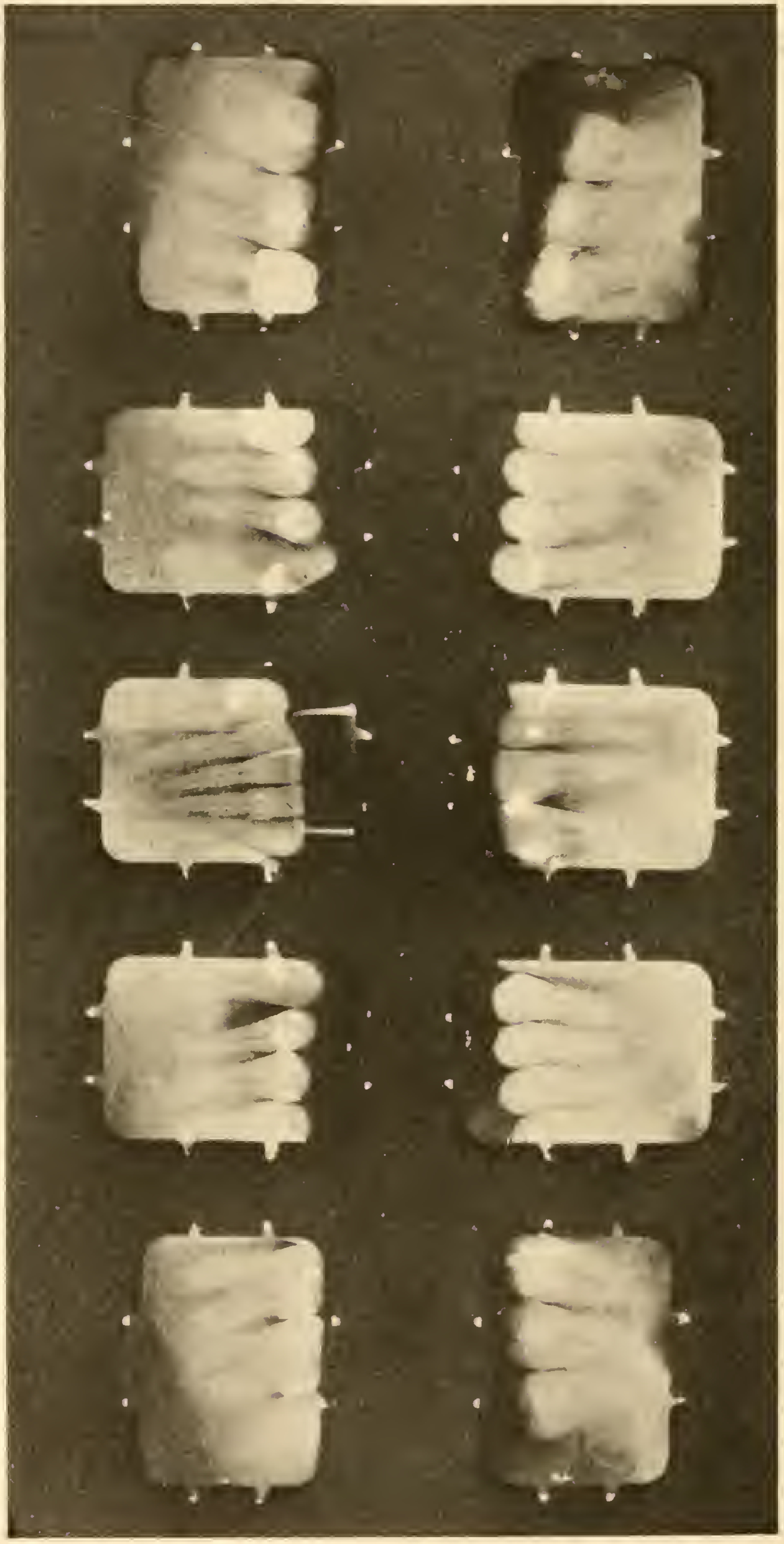


Fig. 27A. Like Fig. 27, a 10-film survey. In this case the cuspid-bicuspid films were placed longways instead of crossways in the mouth. Here we fail to get the apices of the lower right third molar. Also we fail to get a satisfactory view of the upper right lateral. This sort of thing is characteristic of the 10-film survey.

TEN-FILM SURVEY—TECHNIC CHART

Teeth	*Vertical Angle**	*Horizontal Angle*	*Filmholder*	*Position of Film*	*Time of Exposure Factors* Film-Target Distance, 18 In. Milliamperage, 20 ma. Spark-Gap Back-Up, 4½ In. (57,000 Volts)	*Time of Exposure Factors* Film-Target Distance, 8 In. Milliamperage, 10 ma. Spark-Gap Back-Up, 3 In. (45,000 Volts)	*Time of Exposure Factors* Film-Target Distance .... Milliamperage, ... Spark-Gap Back-Up .... (To be filled in by individual operator).
Upper Incisors	45 Above	Straight through between Central Incisors.	Film packet longways. Holder No. 1 or No. 2, preferably No. 1.	Center of film packet between Central Incisors.	About 8 seconds	About 7 seconds	
Upper Cuspid and Bicuspids (also including the Lateral Incisor).	45 Above	Straight through Cuspid or a little disto-lingually.	Film packet crossways. Holder No. 1 or No. 2, preferably No. 1. (Some prefer to place the packet longways).	Mesial (front) edge of packet center of Central Incisor, or a little farther mesially. (Make certain to get the lateral).	About 7 seconds	About 6 seconds	
Upper Molars	30 (+) Above	Parallel with distal surface of First Molar.	Film packet crossways. Holder No. 1 or No. 2—preferably No. 1.	Mesial edge of packet about center of Second Bicuspid, or a little farther distally. (Make certain to get the First Molar).	About 10 seconds	About 7½ or 8 seconds	
Lower Incisors	20 Below	Straight through between Central Incisors.	Film packet longways. Holder No. 3.	Center of packet between Central Incisors.	About 7 seconds	About 6 seconds	
Lower Cuspid and Bicuspids.	20 (+) Below	Straight through Cuspid or a little disto-lingually.	Film packet crossways. Holder No. 1 or No. 2. (Some prefer to place the packet longways).	Mesial edge of packet at center of Central Incisor, or farther mesially. (Make certain to get the Cuspid).	About 7 seconds	About 6 seconds	
Lower Molars	10 Below	Straight through between the First and Second Molars.	Film packet crossways. Holder No. 1 or No. 2.	Mesial edge of packet about the Distal of the Second Bicuspid. (Make certain to get the First Molar).	About 7 seconds	About 6 seconds	

The time given is for Buck X-Ograph or Eastman "Regular" (slow) films; figure ¼ to ⅓ as much time for Buck X-Ograph "Speed" or Eastman "Extra-Fast" films.

Instead of giving more time for the upper incisors and molars, the operator may, if he uses a Coolidge tube and has an autotransformer control, increase his penetration some.

It will be noticed that the time of exposure is given as *"about"* so-and-so. The reason for this is that the time of exposure cannot be figured with absolute mathematical precision. A certain milliampere-second exposure which is correct with one radiographic outfit may prove to be a little off with another outfit.

The general aim has been to overestimate the time of exposure rather than underestimate it, the latter being the common mistake in charts and printed directions.

* The vertical angles given here are, for the most part, *"safe"* angles, *not* the best angles, but they are so to speak the expedient angles for a set-of-ten negatives. The set-of-ten negatives does not represent a thorough X-ray examination of the mouth. It is, at best, only an X-ray *glance* at the mouth as distinct from an X-ray *scrutiny* such as may be made. In the effort to get all the teeth on 10 films some of the negatives are made at angles which are admittedly not right to make correct X-ray images of the parts.

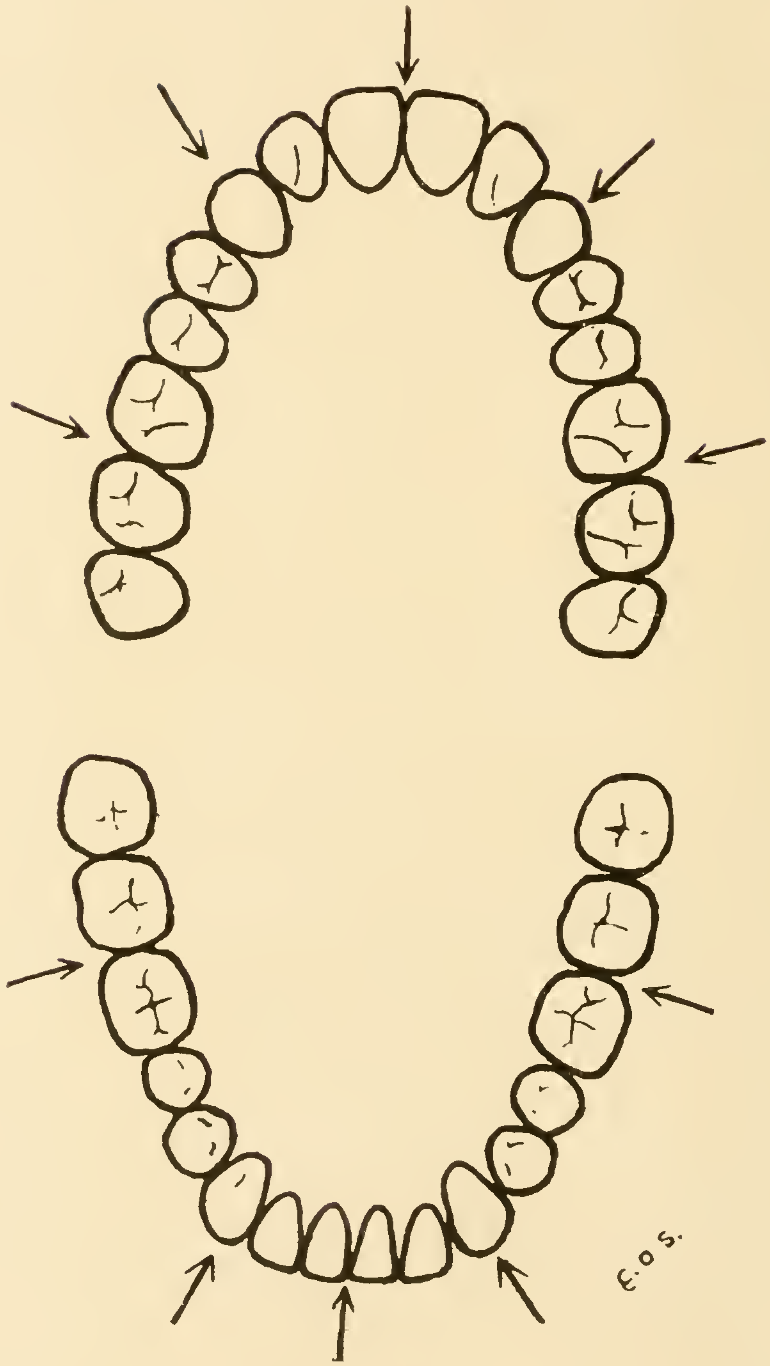


Fig. 27A. Occlusal view of the teeth. The arrows indicate the horizontal angles for a 10-film survey. (Drawing of teeth by Simpson).

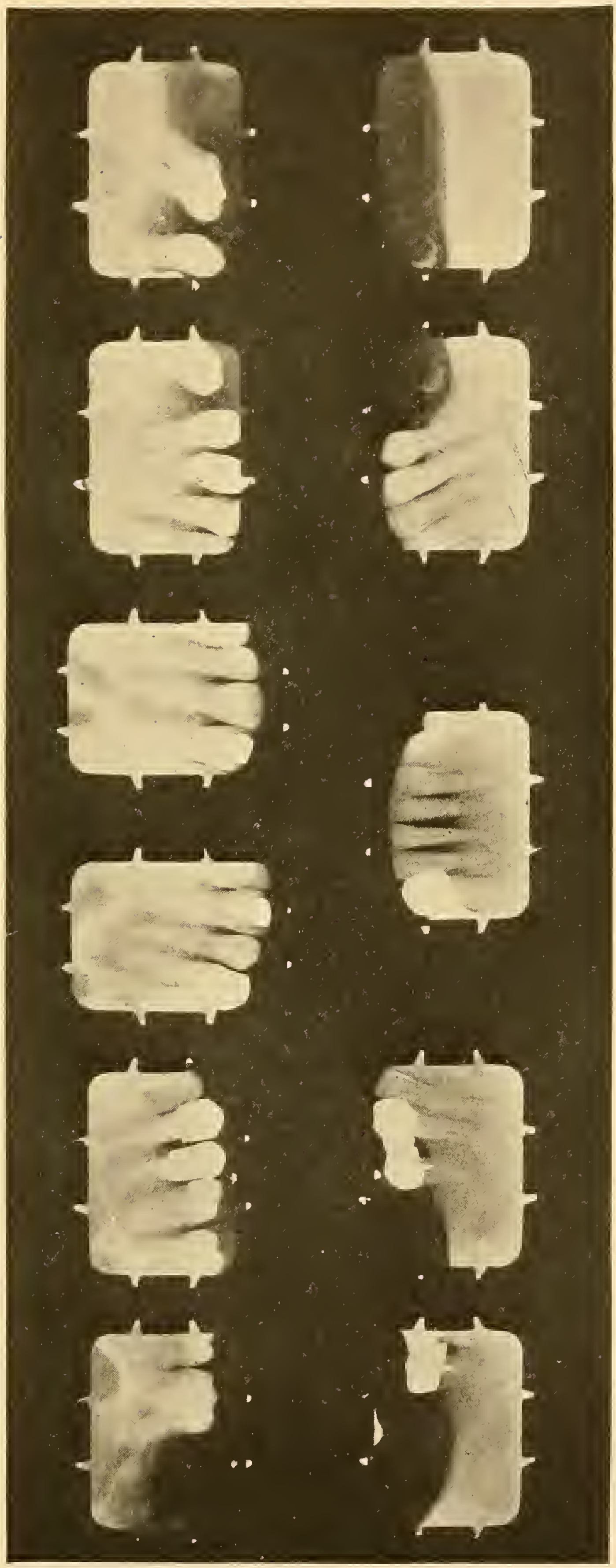


Fig. 28. Eleven-film survey of the mouth. Like the ten-film survey, except that two films instead of one are used for the upper front teeth.

Q. When 2 negatives are used to get the upper incisors what undesirable thing may occur?

A. The teeth are arranged on the two films as follows: One film, upper left lateral and central and on the other film upper right central and lateral. The undesirable thing which may occur when the teeth are placed on the films in this manner is that the angle is such that the shadow of the anterior palatine foramen (incisive foramen) may be cast at the apices of the central incisors and have the appearance of an abscess cavity.

Q. How are the teeth arranged on the negatives for a 12-film whole mouth examination?

A. Seven negatives for the upper teeth, 5 for the lower. For the upper teeth as follows: Negative No. 1 upper left molar region, No. 2 upper left bicuspid region including the first molar, (sometimes the second) No. 3 upper left cuspid and lateral region, No. 4 upper central incisors, No. 5 upper right lateral and cuspid, No. 6 upper right bicuspids including first molar, (sometimes the second) No. 7 upper right molars. For the lower teeth: 5 negatives the same as in the 10-film examination.

Q. What are the advantages of using 7 negatives for the upper teeth?

A. (1) The cuspids and the bicuspids are placed on different negatives; therefore we can get the correct angles for both cuspids and bicuspids. (2) The shadow of the malar bone can be cast forward, then backward, so that we get a clear view of all of the molar teeth. This may be done as follows: For negatives No. 1 and No. 7 let the mesio-distal angle be substantially at right angles to the long axis of the tongue * thus casting the shadow of the malar bone anteriorally and so we are reasonably sure of getting an unobstructed view of the second and third molars. For negative No. 2 and No. 6 let the mesio-distal angle be somewhat disto-lingually. This casts the shadow of the malar bone somewhat distally and gives a clearer view of the first molars. To avoid the malar bone the vertico-horizontal angle should always be as low as possible. In cases of a very high vault with the crowns of the teeth tipped lingually as low as or lower even than 20 degrees above the horizontal (Angle Meter). (3) Using 7 negatives for the upper teeth there is not the danger of casting the shadow of the anterior palatine foramen at the apex of the central incisors.

*See the chart of mesio-distal angles for a 14-film survey in this chapter.

Q. What are the limitations and disadvantages of the 12-film whole mouth examination?

A. It is not always possible to get a good radiographic view of all of the lower teeth on 5 negatives.

Q. How are the teeth arranged on the negatives in a 14-film whole mouth examination?

A. Seven negatives for the upper, 7 for the lower. For the upper teeth, the same as in the 12-film whole mouth examination. For the lower teeth, the 7 negatives include the various teeth in the same way that the 7 negatives for the upper teeth include the various teeth.

Q. What are the advantages of using 7 negatives for the lower teeth?

A. The view one gets of the lower teeth is better. For examples: Five negatives of the lower teeth do not always give a good view of the interseptal bone in the lower lateral and cuspid regions, truer radiographs of the cuspid and bicuspids are obtained and a much better examination of molars is had.

Q. How are the teeth arranged on the negatives for a 16-film examination?

A. Substantially the same as for the 14-film examination with two extra negatives for the upper anterior region.

Q. What are the two most popular whole mouth surveys?

A. The 10-film and the 14-film.

Q. How does the 10-film survey compare to the 14-film survey?

A. The 10-film survey is far inferior to the 14-film survey. The 10-film survey should be considered as sort of an X-ray *glance* at the parts while the 14-film survey is a scrutiny.

Q. Even when 14 (or 16) films are used to commence with, does this insure the operator against the necessity of having to make radiographs of certain regions over again?

A. No. When the operator sees the finished negatives, no matter how many of them there may be, he may find that he wishes to re-ray certain regions. This is *very much less likely* to occur with the 14-film examination than with the 10-film survey, however.

Q. Name 3 ways in which a whole mouth examination may be made.

A. (1) By radiographing all parts of the mouth. (2) By radiographing all suspicious parts of the mouth. (3) By radiographing only

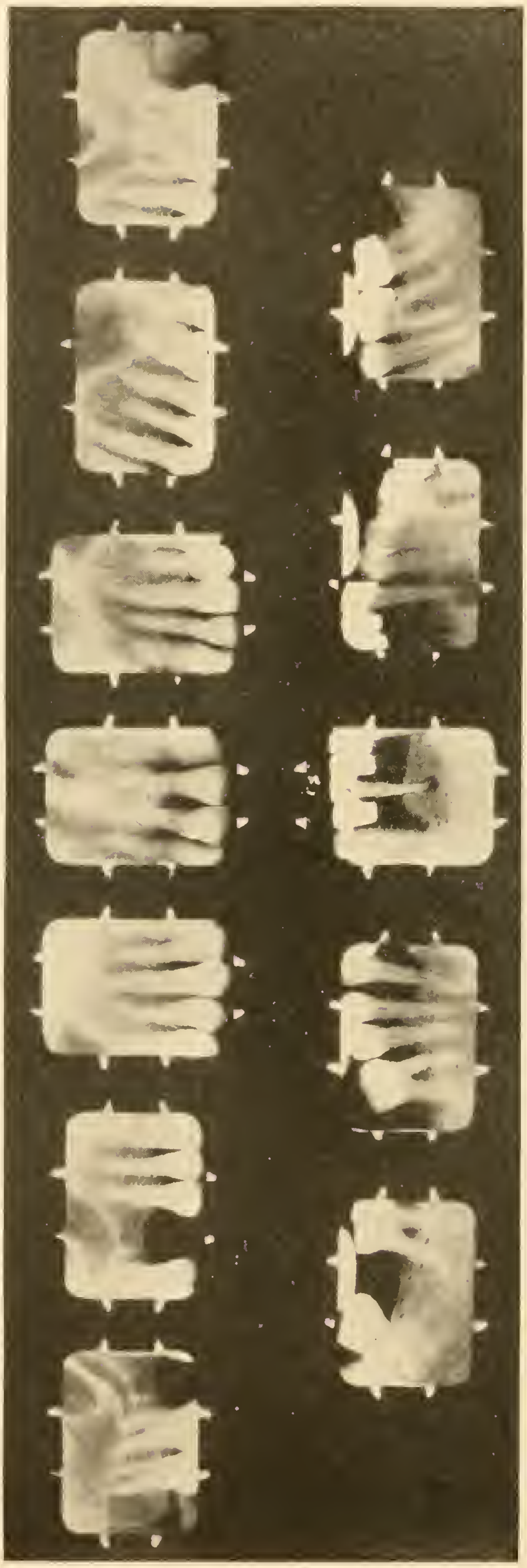


Fig. 29. The 12-film survey, here illustrated, is a sort of "cross" between the 10-film and the 14-film survey. It gives a good primary survey of the upper teeth but no better view of the lower teeth than is obtained in the 10- or 11-film surveys.

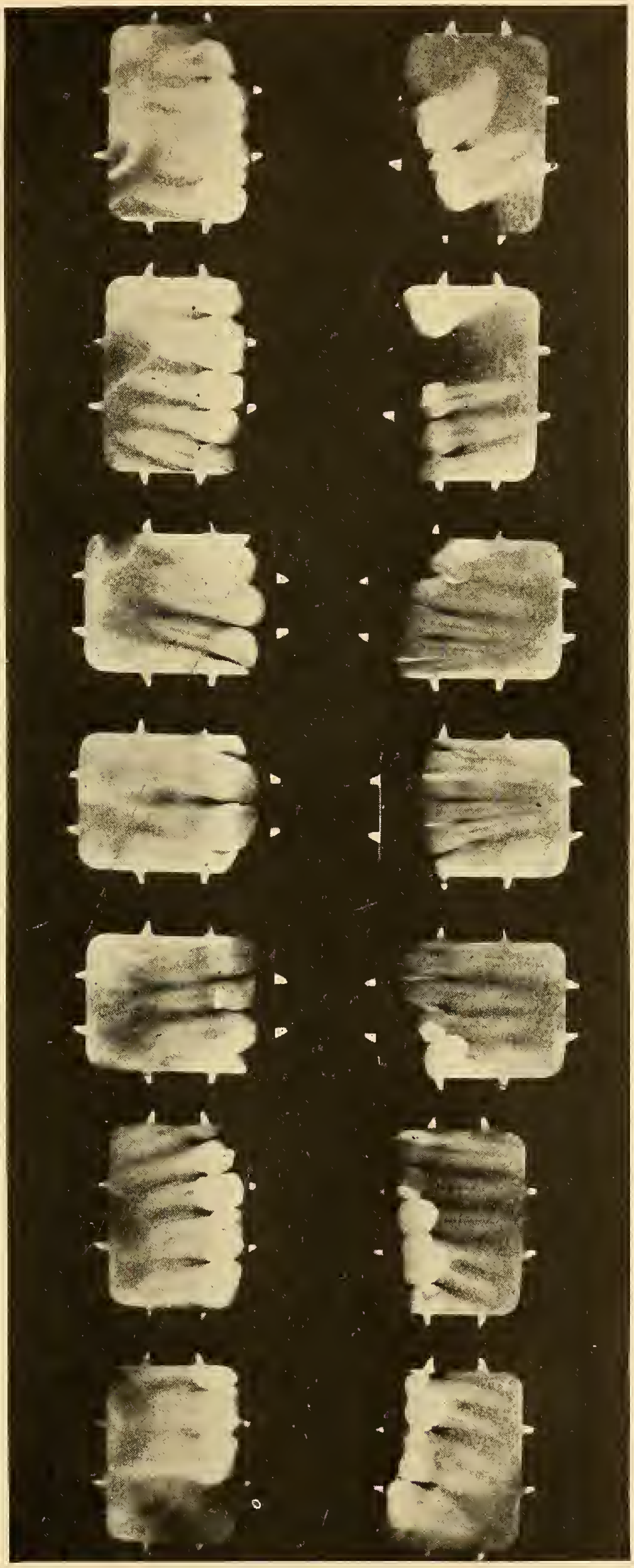


Fig. 30. The 14-film survey. An adequate *primary* survey rapidly becoming recognized as very far superior to the 10-, 11- or even 12-film surveys. The phrase *primary* survey is used in recognition of the fact that even though the original, or primary, survey be thorough, still the diagnostician may wish to make further examination (or survey) of certain regions.

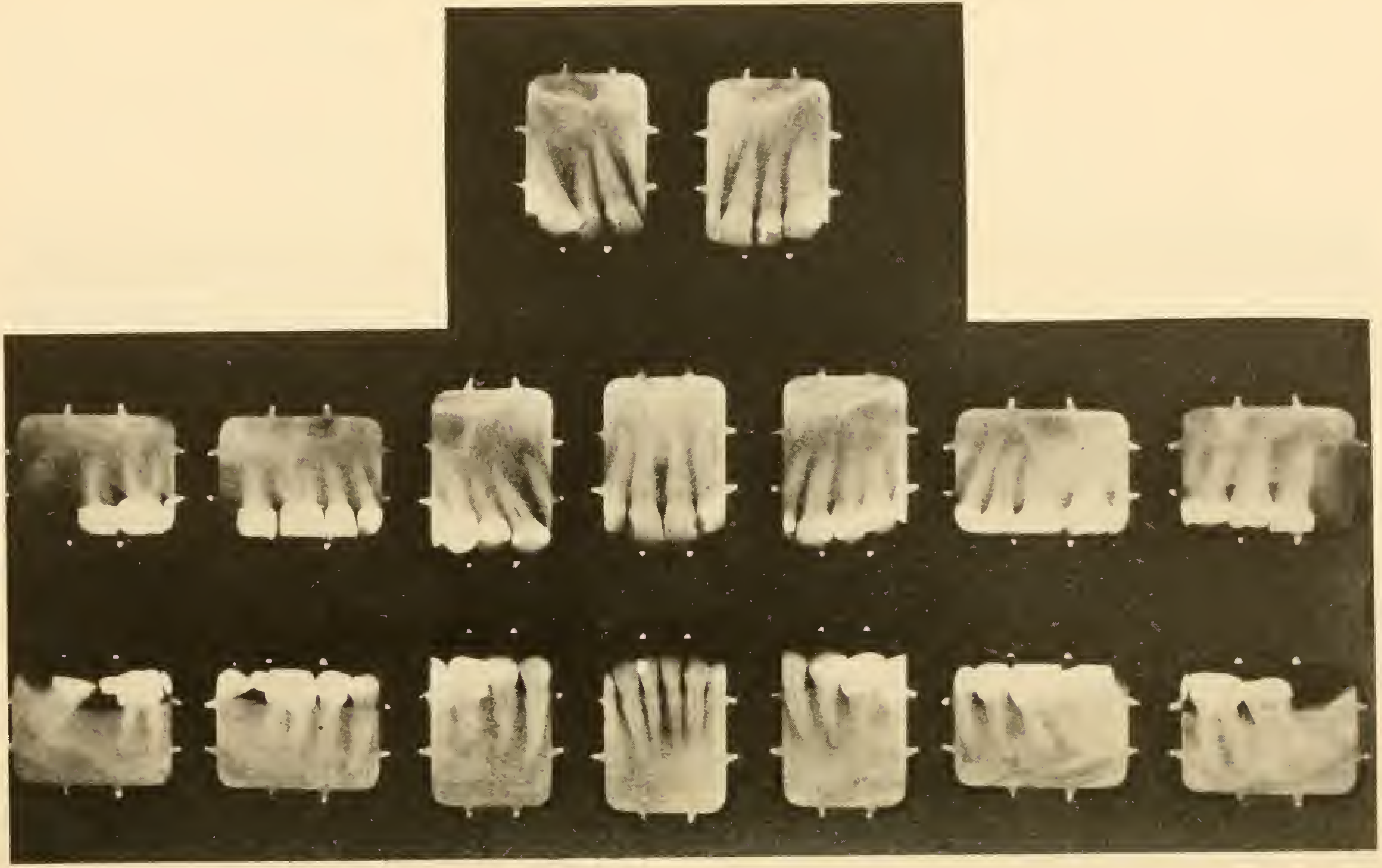


Fig. 31. The 16-film survey by Simpson. Like the 14-film survey except two extra negatives are made of the upper front teeth. Reason: Dr. Simpson calls attention to the fact that the following things register on X-ray negatives of the upper front part of the mouth: Anterior palatine foramen, nasal spine, nostrils, nasal fossae and nose; also, when the cheek is held back, a heavy fold of tissue diagonally across the cuspid region. The two extra negatives are made to avoid confusing some of these landmarks with pathologic lesions.

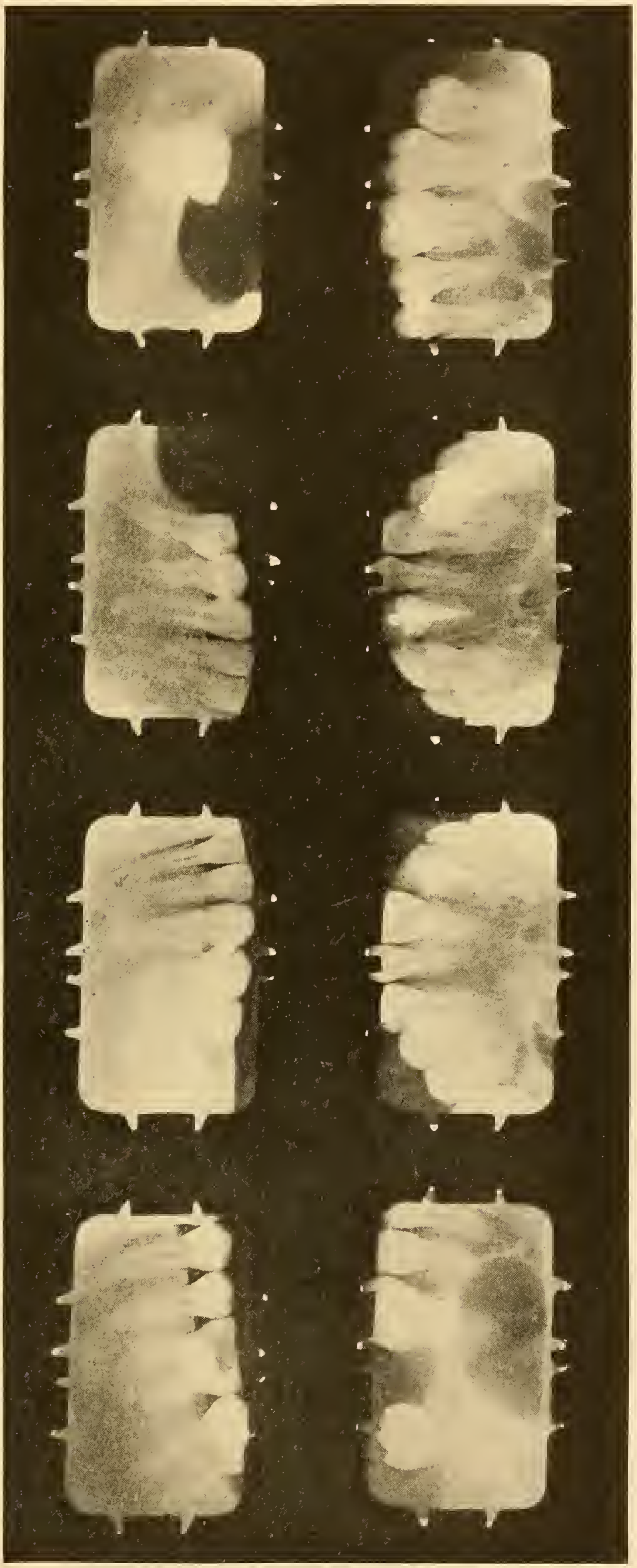


Fig. 32. An 8-film survey of the mouth made on special size films, 2 x 1¼ inches. A set of negatives like this has no place in the practice of radiodontia. The 10-film survey is inadequate enough; this is worse. It is exhibited here as a sort of "stunt survey."

FOURTEEN-FILM SURVEY—TECHNIC CHART

Teeth	*Vertical Angle*	*Horizontal Angle*	*Filmholder*	*Position of Film*	*Time of Exposure Factors* Film-Target Distance, 18 In. Milliamperage, 20 ma. Spark-Gap Back-Up, 4½ In. (57,000 Volts)	*Time of Exposure Factors* Film-Target Distance, 8 In. Milliamperage, 10 ma. Spark-Gap Back-Up, 3 In. (45,000 Volts)	*Time of Exposure Factors* Film-Target Distance .... Milliamperage Spark-Gap Back-Up .... (To be filled in by individual operator).
Upper Central Incisors	40 Above	Straight through between Central Incisors	Use film packet longways. Holder No. 1 or 2—preferably No. 1.	Center of film packet between Central Incisors	About 8 seconds	About 7 seconds	
Upper Cuspid and Lateral Incisor	45 Above	Straight through Cuspid	Use film packet longways. Holder No. 1 or 2—preferably No. 1	Mesial (front) edge of packet at *about* center of Central Incisor, or a little farther mesially.	About 7 seconds	About 6 seconds	
Upper Bicuspids and First Molar	30 Above	Parallel with the Mesial surface of the First Molar	Film packet crossways. Holder No. 1 or 2—preferably No. 1	Mesial (front) edge of packet about mesial of Cuspid.	About 8 seconds	About 7 seconds	
Upper Molars (Particularly the second and third).	30 Above	Straight through between the Second and Third Molars	Film packet crossways. Holder No. 1 or No. 2—preferably No. 1	Mesial edge of packet *about* center of Second Biscuspid, or a little farther distally.	About 10 seconds	About 7½ or 8 seconds	
Lower Incisors	15 Below	Straight through between the Central Incisors	Film packet longways. Holder No. 3.	Center of film packet between Central Incisors.	About 7 seconds	About 6 seconds	
Lower Cuspid and First Bicuspid	20 Below	Straight through Cuspid	Film packet longways. Holder No. 3.	Mesial edge of packet between Central Incisors.	About 7 seconds	About 6 seconds	
Lower Second Bicuspid and First Molar	10 Below	Parallel with the Mesial surface of the First Molar	Film packet crossways. Holder No. 1 or No. 2	Mesial edge of packet about mesial or middle of First Bicuspid.	About 7 seconds	About 6 seconds	
Lower Molars (Particularly the Second and third).	5 Below	Straight through between the Second and Third Molars	Film packet crossways. Holder No. 1 or 2. (Sometimes holder No. 3 to get a view of the tissues distally and above the Third Molar).	Mesial edge of packet about mesial of the First Molar, or farther distally. (Make certain to go back far enough).	About 7 seconds	About 6 seconds	

The time given is for Buck X-Ograph or Eastman "Regular" (slow) films; figure ¼ to ⅓ as much time for Buck X-Ograph "Speed" or Eastman "Extra-Fast" films.

Instead of giving more time for the upper incisors and molars, the operator may, if he uses a Coolidge tube and has an autotransformer control, increase his penetration some.

It will be noticed that the time of exposure is given as *"about"* so-and-so. The reason for this is that the time of exposure cannot be figured with absolute mathematical precision. A certain milliampere-second exposure which is correct with one radiographic outfit, may prove to be a little off with another outfit.

The general aim has been to overestimate the time of exposure rather than underestimate it, the latter being the common mistake in charts and printed directions.

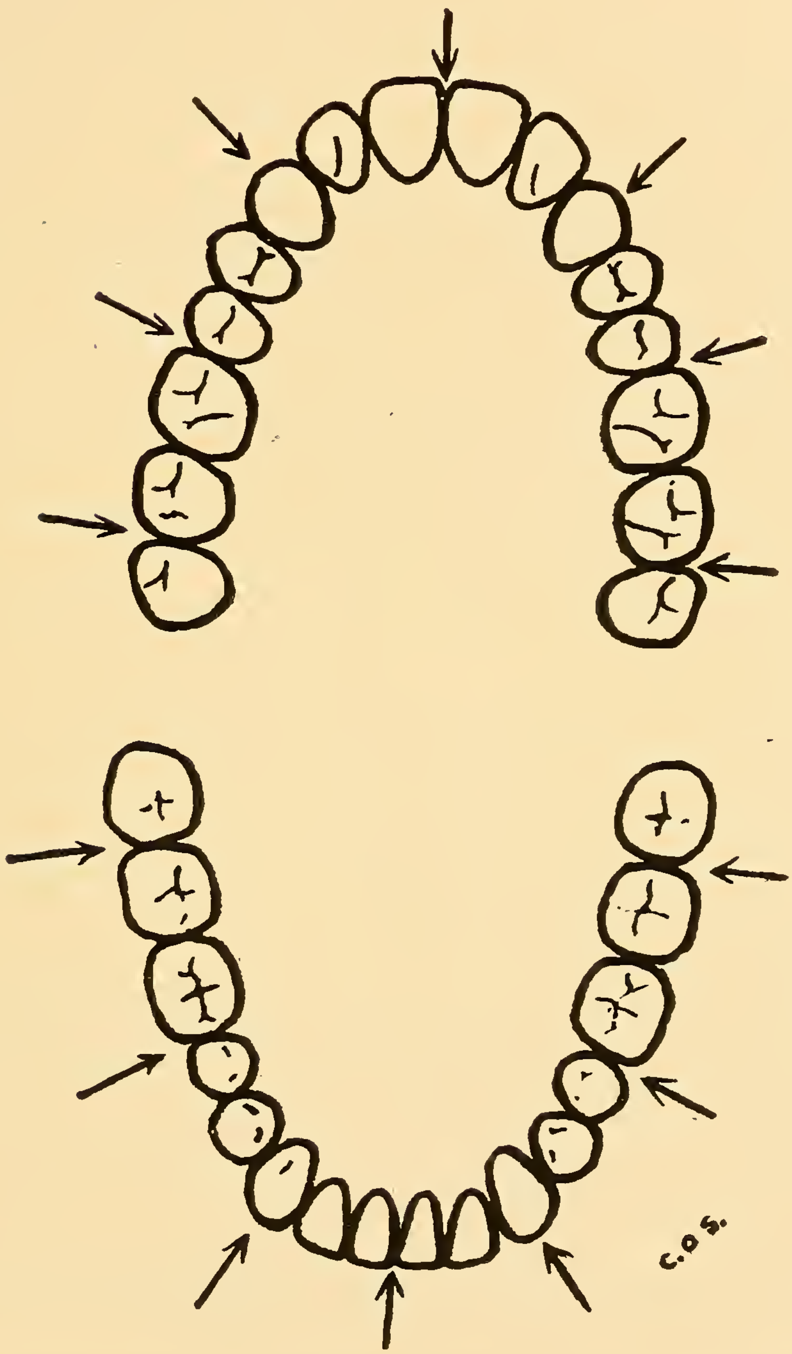


Fig. 32A. The arrows indicate the horizontal (mesio-distal) angles for a 14-film survey.

the pulpless teeth—or, to be more exact, those judged to be pulpless or probably pulpless.

The "suspicious parts of the mouth" include (a) the teeth judged to be pulpless or perhaps pulpless—that is the teeth which do not respond perfectly to the electric test, or cannot be tested with the electric test, (b) the regions from which teeth are missing, and (c) those teeth judged to be affected with pyorrhea.

Q. Comparing the practice of radiographing only the pulpless teeth to the practice of radiographing all parts of the mouth, what lesions might be found by the latter method which would not be found by the former?

A. When all parts of the mouth are radiographed we may find some of the following lesions which might be overlooked if the examination were intended to include only the pulpless teeth. (1) Incipient pyorrhea. (2) Pieces of tooth roots or unerupted teeth in regions from which teeth are missing. (3) Odontomata and supernumerary teeth. (4) Incipient caries and caries under fillings and crowns. (5) Unsuspected pulpless teeth.

Q. When radiographs of all parts of the mouth are made is it necessary to use the electric test for pulp vitality?

A. It is expedient to use the electric test for pulp vitality even when all parts of the mouth are radiographed. The radiographic findings and the electric pulp test findings check one another, thus making for greater accuracy in interpretation and diagnosis.

Q. When certain parts of the mouth are to be eliminated from the examination is it permissible to do this without using the electric test to make certain that the teeth which seem to be vital do carrry vital pulps?

A. The writer considers the use of the electric test in such cases imperative.

Q. What advantage has the limited examination over the practice of making radiographs of all parts of the mouth?

A. Only one: The economical advantage to the patient.

Q. When the tissues seem to be obviously in a state of health and the electric test for pulp vitality indicates that the pulps of the teeth are vital, why make radiographs?

A. As stated we may find in such cases such unusual lesions as odontomata or supernumerary teeth. Also we may find incipient caries

or unsuspected incipient pyorrhea. It is a sound principle that applies to many other things in life besides a search for dental disease that one of the best ways to find a thing is to look where you think it probably is not, as well where you think it probably is.

Q. When is a "whole mouth" examination indicated?

A. In cases of suspected metastatic infection causing systemic disease, in cases of obscure neuralgias which involve both sides of the head and face, in cases where the operator or patient or both want to know the *exact* condition of the mouth as nearly as it is possible to learn it.

CHAPTER XIII

LOCALIZATION

Q. What is meant by localization?

A. Determining the *exact* location of an object.

Q. Is there "depth" (i. e. perspective) in an ordinary radiograph?

A. Almost none.

Q. What are the methods of localization?

A. (1) Stereoscopic radiography. (2) Cross fire. (3) Shift (or shift-sketch) method. (4) Plastic or bas relief.

Q. What is the meaning of the word stereoscopic?

A. The word stereoscopic means literally "seen solid."

Q. Describe briefly the principle of stereoscopic radiography.

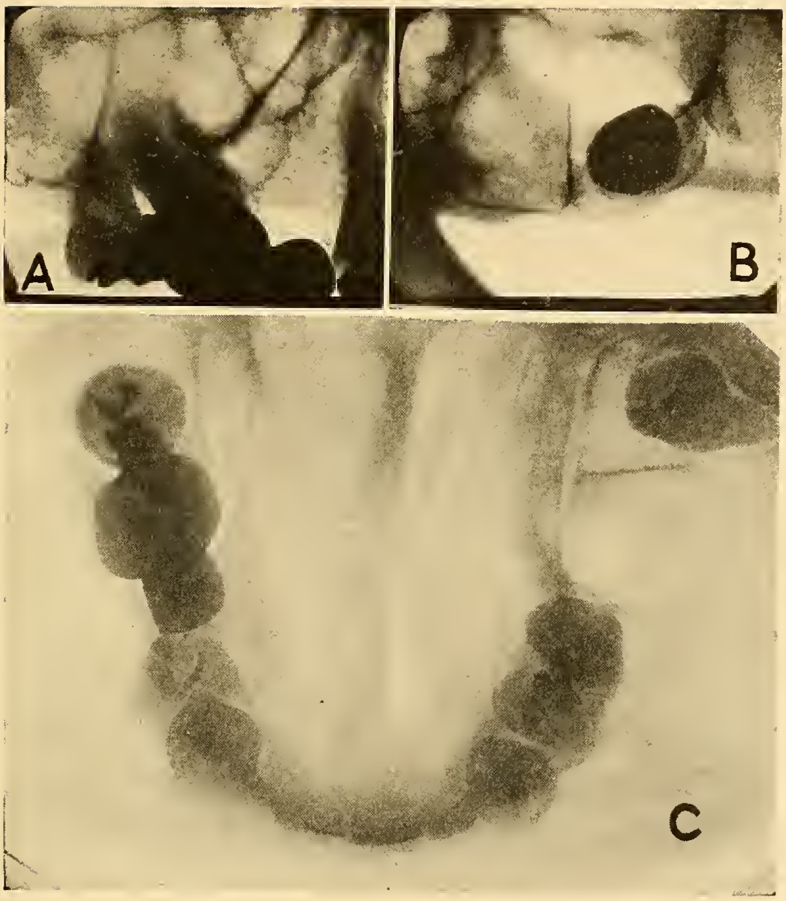
A. Stereoscopic radiography consists in making two radiographs, *one for each eye,* then viewing these two pictures with a device known as a stereoscope by means of which the two "flat pictures" are merged into one with depth or perspective.

Q. Describe briefly the technic of stereoscopic radiography.

A. Let (a) patient (b) film and (c) tube assume a certain position. Make the first exposure. Remove the first film and place another film in the same position formerly occupied by the first. The patient must maintain the same position. Shift the tube laterally about 2½ inches, i. e. the distance between the eyes, sometimes referred to as the pupilary distance. Make another exposure. After the negatives are made they are prepared for observation in the stereoscope by suitable mounting.

Q. What is meant by the "cross fire" method of localization?

A. The "cross fire" method of localization can best be described by taking a concrete case: Say a bullet in the leg. Two radiographs are made: one with the rays passing through the leg in an antero-posterior direction, the other with the rays passing through the leg in a lateral direction. The radiograph made with the rays passing through the leg in an antero-posterior direction gives the lateral (i. e. side to side) location



Figs. 33A, 33B and 33C. A and B are radiographs of the two upper third molar regions of a selected case. They indicate in a satisfactory manner the mesio-distal location of the third molars; also, in a fair manner, the "up-and-down" location so to speak.

Radiograph C, of the same case as A and B, indicates the bucco-lingual location of the third molars. This radiograph was made with the film (Eastman duplitized) flat, that is horizontal, in the mouth and the X-rays directed downward more or less parallel with the roots of the teeth, through the anterior part of the cranium. To make such a radiograph as this the spark-gap back-up should be about five inches. The time of exposure is about the same as for an "antero-posterior head" radiograph. This may be conveniently estimated on an Eastman X-ray Exposure Slide Rule. Radiographs by Dr. C. O. Simpson.

of the bullet, the radiograph made with the rays passing laterally through the leg gives the antero-posterior location of the bullet.

Q. Can the cross fire method of localization be applied to dental radiography?

A. Yes. (See Figs. 33A to 33C.) Dr. C. O. Simpson has developed a practical application of this method to radiodontia. The exposure for making these occlusal view radiographs for the upper teeth is about the same as for an antero-posterior head picture; less for the lower teeth.

Q. Describe briefly the shift-sketch method of localizing unerupted teeth.

A. Make two or more radiographs, shifting the tube laterally between exposures. As a result of the changes in X-ray angle the shadow of the unerupted tooth moves mesially or distally in relation to the other teeth. Make a sketch of a cross section of the parts showing unerupted tooth and adjacent teeth. Then sketch the plane of the film and the angle of the X-rays for the different exposures. Change the location of the sketch of the unerupted tooth as necessary to account for what is recorded in the X-ray negatives. (See Figs. 34 A to 37).

Q. Give postulate for localizing unerupted teeth by shifting the X-ray tube laterally.

A. To localize unerupted teeth, make two or more radiographs, shifting the tube laterally. If the shadow of the unerupted tooth moves, in the radiographs, in the direction in which the tube is shifted, it (the unerupted tooth) lies to the lingual. If the shadow of the unerupted tooth moves in the direction opposite to that in which the tube is shifted, it lies to the facial.

Q. Describe briefly the technic for plastic or bas relief radiography.

A. From the original X-ray negative make a contact print on glass, say on a lantern slide. Place in a printing frame and expose the same as though photographic paper were used instead of a plate except the exposure is much shorter. When print is finished place the uncoated sides of the negative and the lantern slide together and hold with say passepartout binding strips. If the operator will observe now by transmitted light he will see the bas relief effect. Another print on glass or paper can be made by transmitting the exposure light through the negative and lantern slide as they are bound together. This gives a plastic or bas relief print.

There is a great deal of difference in the details of technic, but the

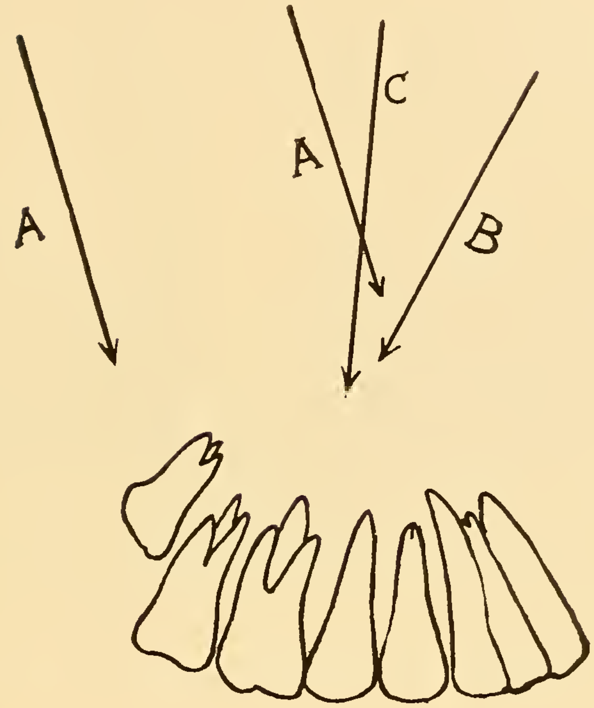


Fig. 33D. A rough sketch indicating the long axis of the upper teeth.

To determine the labio or bucco-lingual location of an unerupted tooth place an Eastman fast dental film or a duplitized film wrapped for protection from light and moisture, flat in the patient's mouth and have patient hold by "closing" the teeth. (Fig. 44).

It is well to support the film packet with a piece of metal, size about 2¼ x 3 inches, to prevent undue bending when the teeth are closed. Simply place the film packet with the piece of metal, then insert packet and metal into the mouth. Have the metal underneath the packet when radiographing the upper teeth, above the packet when radiographing the lower teeth.

For the upper teeth the X-rays should be directed downward *through the head* parallel with the long axis of the teeth. *But* we cannot parallel all the teeth at the same time. Arrows A in the sketch here parallel the anterior teeth, while arrow B parallels the posterior teeth.

If the angle for the anterior teeth, indicated by arrows A, were used to localize the third molar in the sketch, and the third molar were directly back of the second, the shadow of the third molar and second molar would be superimposed one upon the other. (This writer recalls a case where the overlapping was complete and the third molar entirely lost to view).

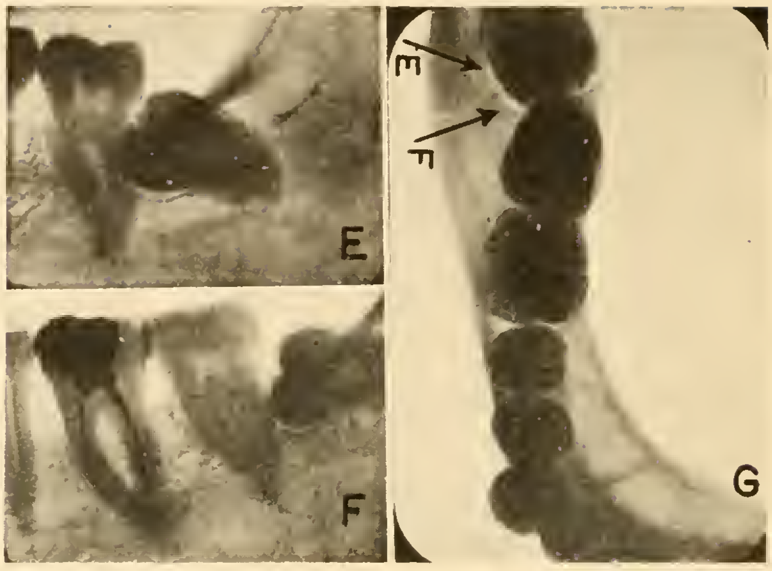
Thus the exact angle depends on the area under examination.

For the anterior region let the angle be diagonally downward and forward as indicated by arrows A. For the posterior region, have the angle straight downward or something like arrow B. If straight downward there will probably be *some* overlapping of the shadows of the second and third molars, but a moderate amount of this overlapping is not particularly objectionable and the angle like arrow B is not always practical because the films cannot be placed far enough back in the mouth for such an angle.

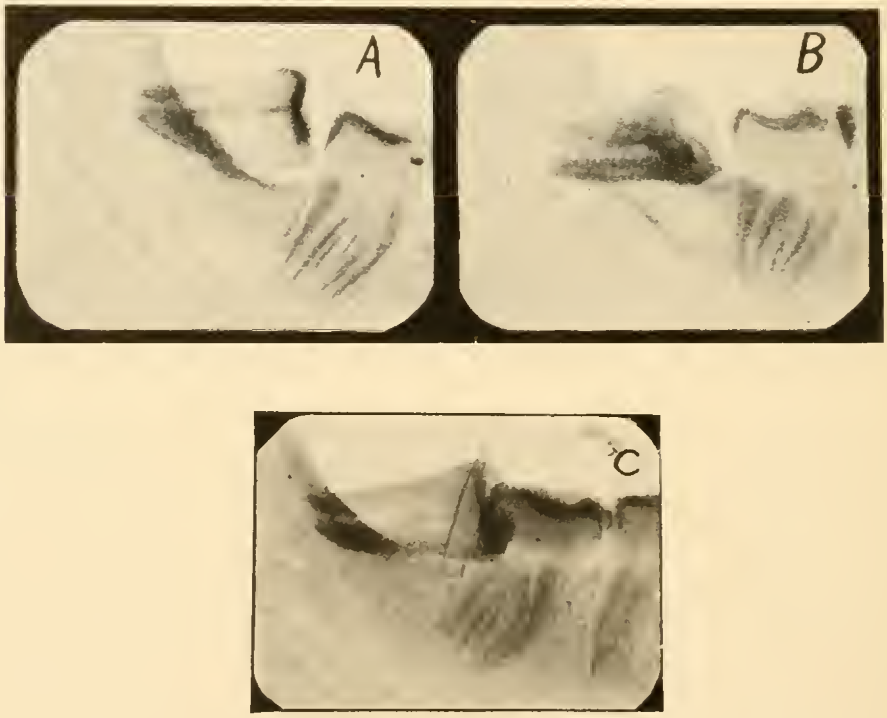
For size use Eastman films No. 1A or No. 2—i. e., 1½ x 2¼ inches or 2¼ x 3 respectively. No. 2 is better for the upper, No. 1A for the lower.

The time of exposure for lowers is only about one third that necessary for uppers if the same speed films are used.

Using fast dental films for the upper and "regular" i. e., slow, for the lower, the time of exposure is about the same.



Figs. 33E, 33F and 33G. All of the same case. Figs. 33E and 33F, the ordinary views. Fig. 33G the localizing occlusal view. The third molar lies a little to the buccal. The horizontal angle used to make Fig. 33E is indicated by arrow E. The horizontal angle used to make Fig. 33F is indicated by arrow F. Here is a case where, after making a single radiograph similar to Fig. 33E, a diagnosis of absorption of the roots of the second molar was given. (Radiographs by Simpson).



Figs. 34A, 34B, and 34C. Three radiographs of the same case (an experimental case Fig. 35) made at different angles. Note that there is lapping of the radiographic shadows of the crowns in C but not in A or B. For a diagrammatic explanation of this, study Fig. 35. (From Dental Items of Interest, Dec. 1919).

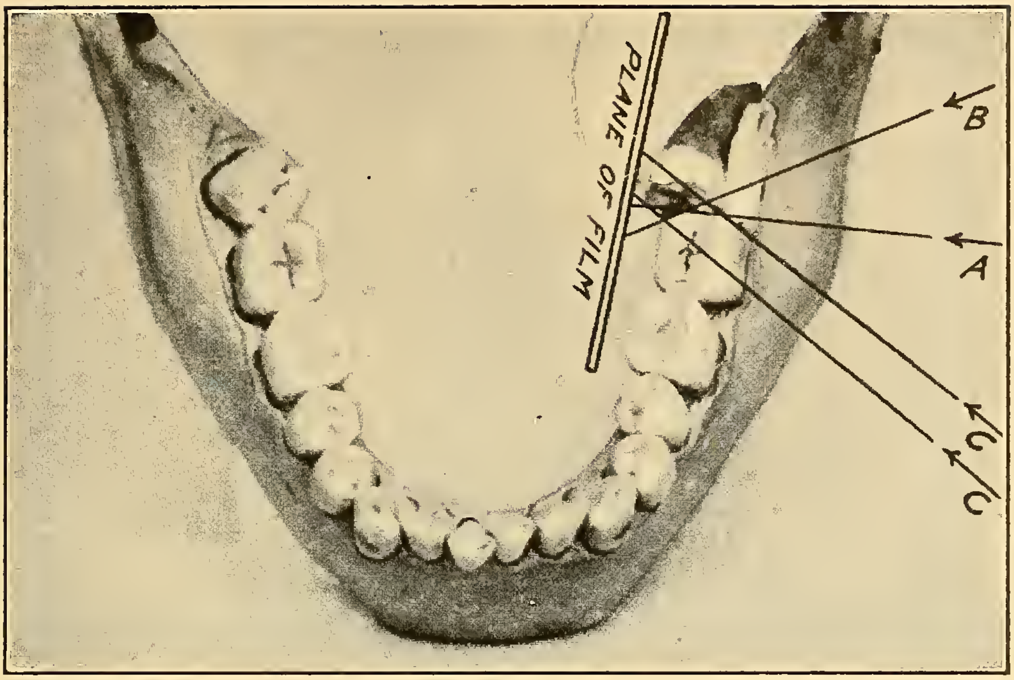


Fig. 35. Diagrammatic elucidation of the postulate that "if the radiographic shadow of the unerupted tooth moves in the same direction as the tube is shifted the tooth lies to the lingual."

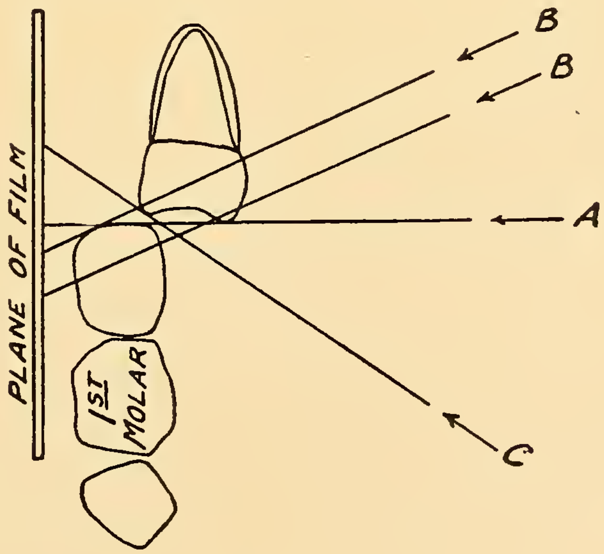


Fig. 36. Diagrammatic elucidation of the postulate that "if the radiographic shadow of the unerupted tooth moves in the opposite direction to that in which the tube is shifted the tooth lies to the facial."

fundamental principle is simply to superimpose a negative and positive and view by transmitted light.

Q. What gives the plastic or bas relief effect?

A. There is only one way to give an image or shadow on a flat surface the appearance of bas relief and that is by shading. The plastic radiograph is simply a shaded radiograph.

Q. What is the best method of localization?

A. Cross fire where it can be applied.

Q. What is the drawback to the cross fire method of localization of unerupted teeth?

A. The X-ray machine must be one of not less than 5-inch parallel spark-gap penetration in order to make a radiograph like Fig. 33C. (The time of exposure for such radiograph is about the same as for an "antero-posterior head").

Q. What are some of the things that mitigate against the popularity and usefulness of the stereoscopic method of localization?

A. (1) The possibility of getting a false or exaggerated stereoscopic effect. (2) The additional work. (3) The exacting technic. (4) The necessity of using a stereoscope.

Q. What mitigates against the popularity and usefulness of the *shift-sketch* method?

A. Lack of exactness and difficulty.

Q. Does the plastic radiagraph show anything that cannot be seen in the original flat negative?

A. No. The plastic radiagraph is made from *one* original flat negative. It cannot show *more* than was *in* the original negative. But it shows plainer.

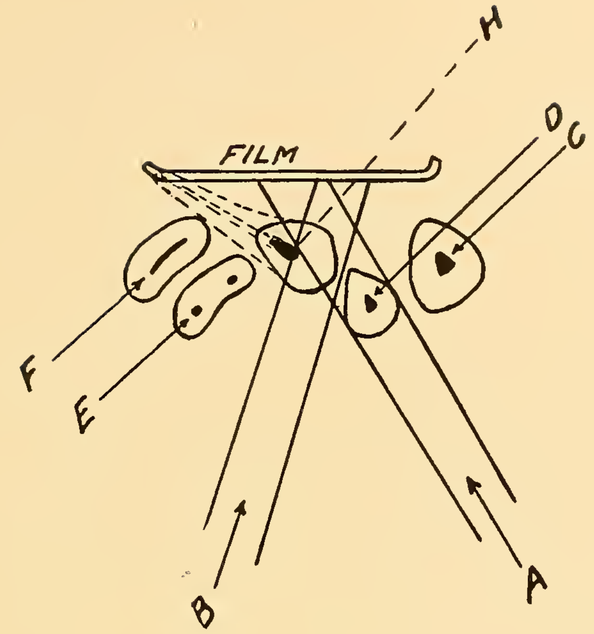


Fig. 37. Diagrammatic elucidation of the shift (sketch) method of localization applied to unerupted upper cuspid. A, the X-rays directed through the parts from in front. B, the X-rays directed through the parts from the side. C, central incisor. D, lateral incisor. E, first bicuspid. F, second biscuspid. G, the film. H, unerupted cuspid to the lingual. I, unerupted cuspid to the facial.

With the rays passing through the parts as indicated by arrow A the shadow of the cuspid to the lingual (H) overlaps the central (C) while the cuspid to the facial (I) does *not* overlap the central (C).

With the rays passing through the parts as indicated by arrow B the shadow of the cuspid to the lingual (H) does *not* overlap the central (C) while the cuspid to the facial (I) does overlap the central (C).

CHAPTER XIV

DANGERS

Q. What is an X-ray burn?

A. A dermatitis due to exposure to the X-rays. Called radiodermatitis. Somewhat similar to sunburn.

Q. What are the symptoms of an X-ray burn of the first degree?

A. Slight itching, then hyperemia. Symptoms appear usually 3 to 15 days after exposure and subside in a few days.

Q. What are the symptoms of an X-ray burn of the second degree?

A. Similar to those of first degree but intensified. May have blister and desquamation.

Q. What are the symptoms of an X-ray burn of the third degree?

A. Following vesiculation and desquamation open ulcers develop, which ulcers in some instances become malignant.

Q. How is the effect of X-rays on the skin influenced by (1) time (2) milliamperage (3) film-target distance and (4) voltage?

A. Time, milliamperage and film-target distance influence the effect of X-rays on the skin in very much the same way these factors influence the effect of X-rays on the photographic emulsion.

(1) Effect varies in direct proportion to the time. (Doubling the time doubles the effect).

(2) Effect varies in direct proportion to the milliamperage. (Doubling the milliamperage doubles the effect).

(3) Effect varies in inverse proportion to the square of the distance. (Doubling the distance reduces effect to one fourth).

(4) Effect on the photographic plate varies in direct proportion to the square of the voltage. (Figured in kilovolts or volts, not spark-gap inches). Thus doubling the voltage gives four times the photographic effect. *But* this is *not* true of the effect of voltage on skin (or on pastilles).* Effect on the skin (and pastilles) varies in direct propor-

* Pronounced pas teals.

tion to the voltage (not *square* of the voltage). Thus doubling the voltage doubles the skin effect. (This is perhaps not exactly mathematically true but is used as a working rule).

Q. If skin effect varies in inverse proportion to the square of the skin-target distance how does the size of the dose vary?

A. In direct proportion to the square of the distance.

Q. What do the following stand for: Sp. Gp. and S. D.?

A. Spark-gap and skin dose.

Q. What is meant by "the erythema dose"?

A. The erythema dose is the dose of X-rays which causes reddening of the skin. Called also "a skin unit," and "one Holzknecht unit." (One Holzknecht unit is expressed thus: H 1).

Q. Are all authorities and operators agreed as to just how much X-ray energy constitutes an erythema dose?

A. *Far from it.* Different authorities and different operators give different figures. However, since the advent of the Coolidge tube, which makes it possible for operators to hold tube voltage (i. e. spark-gap back-up) constant, the difference in erythema dose as expressed by different men is not as great as it was. The estimate of the erythema dose, as commonly given a few years ago was too high. The estimate today is less than one half that given five or six years ago. It is probable that the figures given today are a little low, a little more conservative than necessary, but they are doubtless much nearer right than the over-estimate of the past. The writer has, in one or two experimental cases (not experimental in the sense of testing for skin effect but radiodontically experimental) given the full erythema dose, as now estimated, without getting any reaction at all. He has never found it necessary in a clinical case to give as much as the full erythema dose.

Q. If the operator knows the erythema dose, in time, (that is in seconds) with a certain set of factors or constants—i. e. with a certain known spark-gap back up (voltage), milliamperage and film-target distance—how may he figure the erythema dose with another set of factors?

A. By applying the rules given in answer to the question "How is the effect of X-rays on the skin influenced by (1) Time (2) Milliamperage (3) Film-target distance and (4) Voltage."

This manner of figuring dosage is known as the *indirect method.* The *direct method* of determining dosage with a new set of factors is:

First to figure the erythema dose by the *indirect method,* then test on a patient. Careful radiotherapists make such tests when they change factors or use a new tube or apparatus.

Radiotherapists test for the erythema dose by exposing a spot about the size of a pea on the flexor side of the arm of a young, preferably blond, person, giving less than the estimated erythema dose. After waiting about 3 to 15 days, if a slight redness of the skin does not occur at the exposed spot, another spot is selected and the dose increased; and so on until the dose necessary to produce slight skin redness is learned.

Q. Is it necessary or expedient for individual dentists to determine the erythema dose of their particular outfit and set of factors used by them for radiodontic work, by the direct method as just described?

A. No. The following may be taken as a starting point or standard erythema dose from which the dental operator may figure his erythema dose by the indirect method and he may then make it a rule not to exceed his estimated erythema dose, or even approach it any nearer than absolutely necessary.

Erythema Dose Factors

Spark-gap back-up:	6 inches
Skin-target distance:	8 inches
Miliamperes:	5
Time:	90 seconds

The foregoing may be expressed as follows: With the spark-gap back-up 6 inches (i. e. 69000 volts) and the skin-target distance 8 inches, the milliampere-second dose is 450. (Milliampere-seconds (ma.s.) are obtained by multiplying the seconds by the milliamperes).

Q. What is a pastille and how is it used?

A. A pastille is a piece of paper coated with chemicals which chemicals change color, from yellowish green to brownish, when exposed to X-rays. After a pastille has been exposed to the X-rays and so made to change in color, it is matched to some standard shades on a *radiometer.* A certain shade (H 1) on the radiometer represents an erythema dose. (If the dental operator cares to, he may test his estimated erythema dose by means of pastilles and a *radiometer.*)

Q. Is the pastille method of measuring X-ray dosage absolutely accurate?

A. No, owing to variation of the color and decomposition of chemicals and to colorblindness of people.

Q. What is the erythema dose expressed in milliampere seconds (ma.s.) with the factors as follows: spark-gap back-up 5 inches; skin-target distance 15 inches?

A. *About* 1600 ma.s.

Q. What is the erythema dose expressed in milliampere-seconds (ma.s.) with the factors as follows: spark-gap back-up: 3 inches; skin-target distance 7 inches?*

A. *About* 600 ma.s.

Q. If the erythema dose is 600 ma. s. and 60 ma. s. are used for each radiodontic exposure, how many exposures could be made before reaching the erythema dose?

A. Ten.

Q. What is the difference between a "*test erythema dose*" and "*treatment erythema dose*"?

A. Some men make a distinction between a "*test erythema dose*" and a "*treatment erythema dose.*" The "*test erythema dose*" is the smallest possible dose which will produce perceptible skin redness. The "*treatment erythema dose*" as used by some is a rather severe dermatitis but stopping this side of vesiculation.

The term "*erythema dose*" as ordinarily used and as used in this work refers to the "*test erythema dose.*"

Q. In the practice of radiodontia is it ever necessary or expedient to give or exceed the minimum erythema dose?

A. It is never necessary to give a full erythema dose to the skin of any particular part of the face. An aggregate dose equivalent to an erythema dose but spread over both sides and the front of the face is extremely unlikely to cause erythema, especially since authorities are estimating the erythema dose at a lower figure now.

Q. If the erythema dose is reached or closely approached, how long a time should elapse before further exposure to the X-rays?

A. Three weeks, or longer.

Q. When radiographs are made of the right side of the mouth does this have any X-ray effect on the skin of the left side?

A. Yes, *some.* The skin in line with the X-rays, even though it is the skin of the opposite side of the face, receives *some* X-ray radiation.

* The back-up and skin-target distance mentioned here are about the same as with the average Coolidge unit, right angle tube outfit, the outfit in common use among dentists to-day.

For convenience however the face skin may be divided into thirds: (1) front (2) right side and (3) left side. Thus in a certain experimental case the writer gave about 3480 ma. s. (spark-gap 4, film-target distance 14 inches) in the course of about ten days. But it was estimated that the dose for the skin of any particular part of the face was only one third that amount, or *about* 1190 ma. s. No dermatitis developed, but this was an excessive dose, a dose which could not be given without risk of producing dermatitis, and a dose which need never be given pursuant to ordinary clinical practice.

Q. The operator uses a Coolidge Dental Unit. His voltage is 45,000 (3-inch back-up) his skin-target distance is seven inches. How many exposures may he make of any single radiodontic region* without danger of producing dermatitis?

A. About five exposures. (For the benefit of those who may be interested to know how the writer arrives at the answer just given, the following explanation is given. The erythema dose is figured at 600 ma. s. To make certain to avoid erythema it is decided to give only about one half the erythema dose, that is 300 ma. s. It is then estimated that, with the factors as mentioned in the question, it takes about 60 ma. s. to make an intra-oral negative. Sixty into three hundred goes five times.)

Q. The operator uses a Coolidge Dental Unit. His voltage is 45,000 (3-inch back-up) his skin-target distance is seven inches. How many milliampere-seconds may he give, as an aggregate dose, at one sitting, to all parts of the face, for intra-oral radiodontic work, without danger of producing dermatitis?

A. About 900 ma. s. (For the benefit of those who may be interested to know how the writer arrives at the answer just given, the following explanation is given. The erythema dose is figured at 600 ma. s., *for any one part of the face.* For convenience the whole face is divided into thirds. Thus, if the dose is to be distributed over the whole face, the erythema dose is three times 600, i. e., 1800 ma. s. This figure is perhaps a little high, and is the dosage, bear in mind, to produce erythema of the whole face. One half this amount—i. e. 900 ma. s.—should be safe.)

Q. The operator's voltage is 60,000 (5-inch back-up) his skin-target distance is fifteen inches. How many dental exposures may he make of a single radiodontic region without danger of producing dermatitis?

A. Five or six.

Q The operator's voltage is 60,000 (5-inch back-up) his skin-target distance is fifteen inches. How many milliampere seconds

* A "radiodontic region" includes an average of 3 approximating teeth.

may he give, as an aggregate dose, at one sitting, to all parts of the face, for intra-oral radiodontic work, without danger of producing dermatitis?

A. About 2400 ma. s. (For the benefit of those who may be interested to know how the writer arrives at the answer just given, the following explanation is given. The erythema dose is figured at 1600 ma. s., *for any one part of the face.* For convenience the whole face is divided into thirds. Thus if the dose is to be distributed over the whole face, the erythema dose is three times 1600, i. e. 4800 ma. s. This figure is perhaps a little high, and it is the dosage, bear in mind, to produce erythema of the whole face. One half this amount—i. e., 2400—should be safe.)

(The *aggregate safe dose* of 2400 ma. s. is the same as given in "Elementary and Dental Radiography." This, due to the fact that the writer discounted the then-too-large erythema dose 50%. The *aggregate safe dose* of 900 ma. s. does not match the *safe dose* of 600 ma. s. given in "Elementary and Dental Radiography" very well. This is because the new dose is figured for a voltage of 45,000 while the dose of 600 ma. s. was figured for a voltage of about 60,000.)

Q. What is meant by "cumulative effect" of X-rays?

A. When it is said that the effect of the X-rays is cumulative it is meant that X-ray dosage accumulates. Thus if 500 ma. s. are given one day and 500 ma. s. the next, the effect is almost (not quite) the same as though 1000 ma. s. were given at one dose. Thus if a rather large dose is given, wait about 3 weeks before giving further radiation.

Q. What is an X-ray filter?

A. X-ray filters are usually made of aluminum about 1 millimeter thick. The function of the filter is to absorb the softer X-rays, allowing only the stronger direct X-rays to strike the "part."

Q. The use of a filter 3 millimeters thick will increase the erythema dose expressed in milliampere seconds how much?

A. It will double it. One Holzknecht unit, H 1, is an erythema dose without a filter. With a filter of 3 millimeters the dose is two Holzknecht units, H 2.

Q. Do dental X-ray units have filters?

A. Some of them have filters of about ½ millimeter of aluminum. These filters increase the number of milliampere seconds which can be given before erythema is produced but they also increase the time of exposure necessary to make radiographs. Their value, as protective devices or as a means of improving radiographic results by filtering out vagrant rays, is questionable.

Q. What is meant by an epilating dose of X-rays?

A. A dose sufficient to remove hair. *About* ⅕ of an erythema dose is an epilating dose.

Q. What other kinds of dermatitis may be mistaken for X-ray dermatitis of the hands?

A. (1) Metol poisoning. (2) Procaine poisoning. (3) Formalin poisoning. (4) Iodin poisoning.

Q. What is the treatment of metol poisoning?

A. It is probably the alkalinity of the developer that paves the way and makes metol poisoning develop. The following bath (used in a fingerbowl or similar container) for the hands may be used in the dark-room either as a prophylactic agent or it may be used as a curative agent.

Acetic Acid (U.S.P.)	fl. oz.	2
Water	fl. oz.	3
Sodium Chlorid	dr.	2

M. Sig. Dip the hands in the solution repeatedly during development, as a prophylactic, or as a curative agent rub well into the hands several times a day.

Discontinue the use of metol; use a substitute. *Amidol* and *Ortol*, also *Pyro* are substitutes. *Elon* is not a substitute for *Metol;* they are different trade names for the same chemical substance, namely monomethyl paramidophenol sulphate.

Q. What is the treatment for procaine poisoning?

A. Have the assistant prepare the procaine solution. Use rubber gloves when making an injection.

Q. What is the treatment for formalin poisoning?

A. Discontinue use of formalin.

Q. What point in symptomatology may help in differentiation between X-ray dermatitis and drug dermatitis?

A. In drug dermatitis there is more trouble with the soft tender skin *between* the fingers.

Q. What drugs may be used in the treatment of X-ray or other dermatitis?

A. (1) Zinc stearate as a dusting powder. (2) Ten per cent. zinc oxid ointment. (3) Aluminum acetate. (4) Ichthyol. (5) Normal saline solution. Drugs should be used with great care in the treatment of X-ray dermatitis or they may do much harm. It is to be forcefully rec-

ommended that X-ray dermatitis be treated by a specialist in radiotherapy, if possible.

Q. What may be said of drugs in a general way relative to their value in the treatment of dermatitis?

A. They are not very efficacious. The most important thing in treatment is to remove the cause and protect against further irritation, either mechanical or irritating drugs.

Q. Why does both drug and X-ray dermatitis usually attack the hands?

A. Because the hands are most often exposed to the greatest irritation.

Q. Are there many cases of alopecia following exposure for antero-posterior radiographs?

A. Yes.

Q. How soon does the hair start to fall out after exposure?

A. About a week to a month.

Q. How large an X-ray dose does it take to cause alopecia?

A. This varies greatly. 1000 ma. s., skin-target distance 10 inches, spark-gap back-up 5 inches, may cause alopecia.

Q. What precautions should be taken to prevent X-ray alopecia?

A. (1) Do not attempt an antero-posterior head picture with less than a 5-inch spark-gap back-up. (2) Always use an intensifying screen. In addition to the foregoing, a filter of 1 millimeter of aluminum (or a towel over head) may be used if desired.

Q. Will hair come back when lost due to X-rays?

A. Yes. Unless there has been a severe X-ray burn at the same time. (Hair may be lost without any dermatitis at all.)

Q. How long does it take hair to come back?

A. About two to four or six months.

Q. What is chronic X-ray burn or dermatitis?

A. A skin change occurring in X-ray operators due to long-continued slight exposure to X-rays. The skin gets dry, harsh, tanned, freckled and warty growths (keratoses) occur. The fingernails become ribbed longitudinally.

Q. Can X-rays cause cancer?

A. Yes. Following a severe X-ray burn of the third degree, or when keratoses break down into ulcers in chronic X-ray burn.

Q. Do X-rays cause any other untoward effects besides dermatitis and cancer?

A. X-rays are said to cause malaise, sterility, insanity (?), leukemia (?) and anemia (?).

Q. Why were the old combination gas tube dental units particularly dangerous in the hands of unskilled operators?

A. The old gas tube "dental units" had no parallel spark-gap. Therefore the "back-up" of the tube could not be measured. As a result of this, the X-ray penetration could not be estimated. In the absence of a means to measure it, the penetration sometimes would fall to the point where good X-ray negatives could not be made; this, without the operator's knowledge of the fact. The operator would then try to overcome his difficulties by prolonging the exposure. Under such circumstances the exposures were sometimes prolonged to such an extent as to cause dermatitis.

Q. Is the lead glass incasement which covers Coolidge, radiator X-ray tubes of sufficient protection for the operator against the untoward effects of the X-rays?

A. Judging from results up to date, yes.

Q. Compare the electric current used for electrocution to the X-ray current.

A. The current used at the Ohio State Penitentiary for electrocution is 60 cycle, A.C., voltage 1700 to 2500, amperage 4 to 6 for one minute.

There are two X-ray currents: primary and secondary.

The primary X-ray current is either A.C. or D.C., voltage about 100 to 125, milliamperage about 5 to 40. The secondary X-ray current is A.C., voltage 40,000 to 60,000 or 70,000, milliamperage about 10 to 40.

Q. Have any fatalities occurred from electric shock in the practice of radiodontia?

A. Yes, to both operators and patients.

Q. What is a circuit breaker?

A. A safety device found on some X-ray machines of the Coolidge Unit type particularly. A circuit breaker works automatically. When an excessive amount of current rushes into the machine, due to short circuit or accident, the circuit breaker opens a switch on the mains and so stops the current from entering the machine at all.

CHAPTER XV

FUNDAMENTALS IN INTERPRETATION

Q. What is the general appearance of a dental X-ray negative?

A. Light, rather than dark. The teeth are light.

Q. What is the general appearance of a dental X-ray photographic print made from a negative?

A. Dark, rather than light. The reverse of the negative. The teeth are dark.

Q. By what light are X-ray negatives observed?

A. Transmitted light. That is, the negative is interposed between the light and the observer's eyes.

Q. What kinds of transmitted light may be used to study X-ray negatives?

A. (1) Light from a viewbox or illuminating box. (2) Light reflected from a white surface. (3) Skylight. (View light negatives by skylight or reflected white light. View dark negatives by strong artificial light).

Q. What is a radioscope?

A. A special viewbox with magnifying lenses.

Q. In the absence of a radioscope what may be used to magnify the image?

A. A reading glass.

Q. What is the appearance of a dento-alveolar abscess area in an X-ray negative?

A. Dark, i. e., radiolucent or radioparent.

Q. Why does a dento-alveolar abscess area appear dark in an X-ray negative?

A. Because of the bone decalcification and destruction in such an area which makes the area more radiolucent.

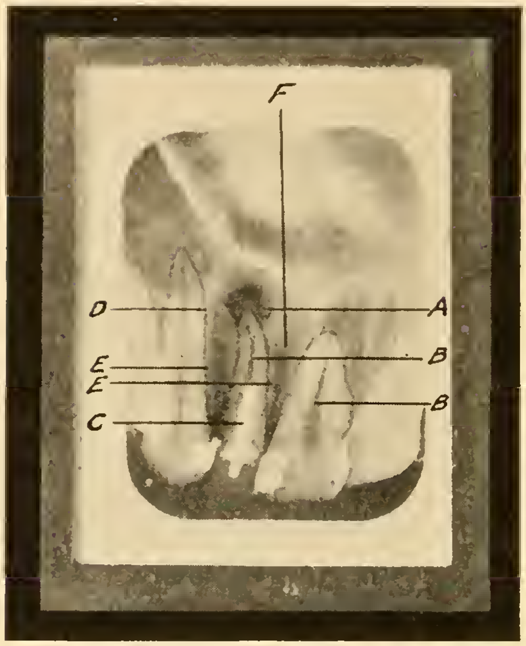


Fig. 38A. Dental X-ray negative. A: Abscess (osteoclasia). B: Open canal. C: Post. D: Pericementum, E: Dental lamella or lamina dura. F: Bone. The light streak, starting at the upper left corner, coming downward and curving to the center of the radiograph, is a cortical bone shadow.

Fig. 38B. Photographic print made from the negative illustrated in Fig. 38A. (Reproduced from "Elementary and Dental Radiography").

Q. What is the appearance of the pericemental membrane in an X-ray negative?

A. A dark line following the outline of the roots of the teeth. The pericemental membrane *per se* cannot be seen. The dark line referred to is the space between the tooth root and the bone, which is occupied by the pericemental membrane.

Q. What is the appearance of the lamina dura (also called dental lamella) in X-ray negatives?

A. A light line just outside i. e., boneward from—the dark line which denotes the pericemental membrane.

Q. What is the lamina dura?

A. The dense layer of cortical bone lining the alveoli.

Q. What is the appearance of the dental pulp in an X-ray negative?

A. Like the pericemental membrane, the dental pulp cannot be seen in X-ray negatives. Pulp chambers and canals when *not* filled with some foreign material introduced by the dentist, appear as dark areas and streaks in the teeth.

Q. Can pulp disease be diagnosed by means of radiographs?

A. No, not directly. If, however, the radiograph shows evidence of an abscess area at the apex of the tooth, the diagnostician may deduce from this that the pulp is non-vital and septic.

Q. Can one distinguish between cementum and dentin in an X-ray negative?

A. No.

Q. Can one distinguish between enamel and dentin in X-ray negatives?

A. Yes, the enamel is a little lighter, i. e., a little more nearly radiopaque.

Q. What is the appearance of metal fillings, bridges, posts, etc. in dental X-ray negatives?

A. Very light, i. e., radiopaque.

Q. What is the appearance of the metal (zinc, copper, silver) cements in dental X-ray negatives?

A. Light, but not as light as the metal shadows.

Q. What is the appearance of gutta percha and temporary stopping in X-ray negatives?

A. Very light. Almost as light as metal. Lighter than some of the metal cements.

Q. What is the appearance of silicate (or silicious) cement fillings in X-ray negatives?

A. Quite radiolucent.

Q. What is the appearance of filled canals in X-ray negatives?

A. Light streaks.

Q. Do all canal filling materials show in radiographs?

A. Practically all, including gutta percha and the proprietary pastes. Rosin and paraffin are radioparent so they register nothing on the negative.

Q. With the X-rays passing through a lower molar in a mesio-lingual direction, the resulting radiograph shows fillings in three canals, two mesials and one distal. Is the middle canal the mesio-lingual or mesio-buccal?

A. Mesio-lingual. See illustration Fig. 39.

Q. What is the appearance of bone in an X-ray negative?

A. A somewhat sponge-like or cancellous appearance. The bone substance appearing white and the marrow spaces dark.

Q. What is the appearance of osteosclerosis?

A. Lighter than normal bone in the negative, due to increased density, i. e., radiopacity.

Q. What is the appearance of the antrum of Highmore, or maxillary sinus in an X-ray negative?

A. A large, dark (i. e., radiolucent) area rimmed more or less with light (somewhat radiopaque) lines.

Q. What are the light (somewhat radiopaque) lines seen in intra-oral radiographs of the upper posterior region?

A. Cortical bone shadows, i. e., antrum walls and nasal walls.

Q. What is the appearance of foramina through the bone in X-ray negatives?

A. Small, dark, (radioparent) more-or-less circular areas similar to abscess cavities.

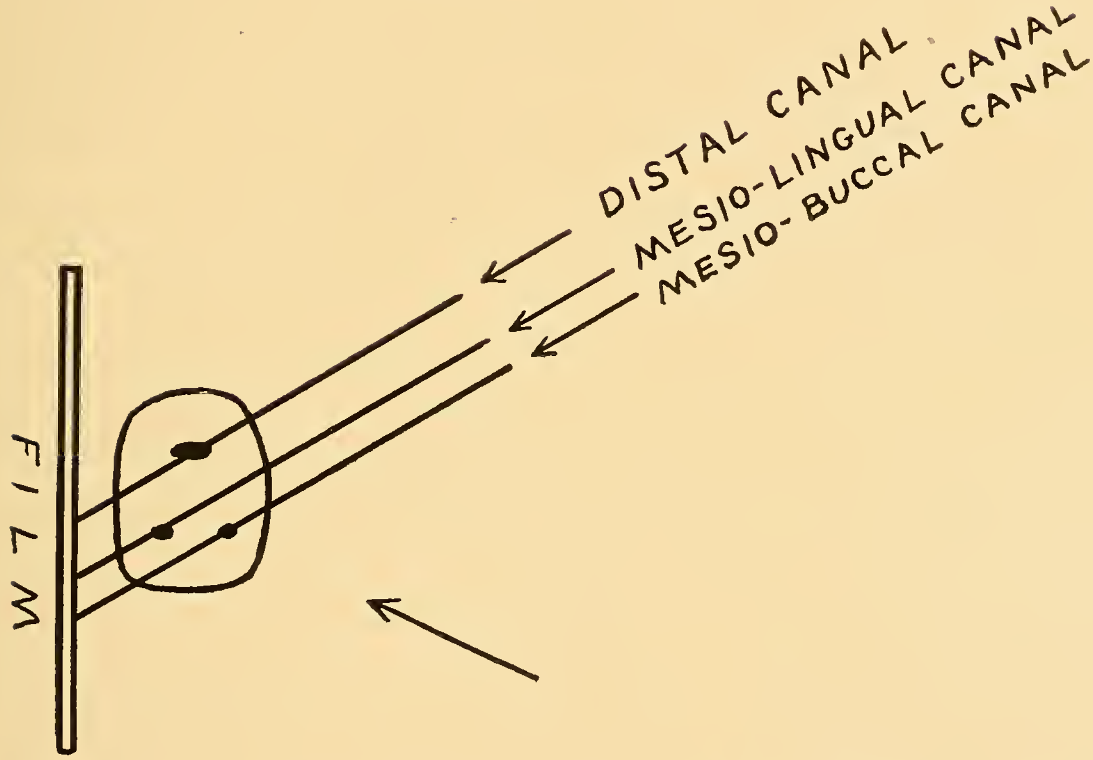


Fig. 39. Sketch of a cross section of a lower molar. The diagonal direction—mesio-lingual direction—of the X-rays indicated by the arrows and lines shows that the shadow of the mesio-lingual canal falls between the other two canals.

With the diagonal angle of the X-rays changed to the disto-lingual instead of the mesio-lingual, the shadow of the mesio-buccal canal falls between the other two canals.

Q. Can a granuloma be seen in a radiograph?

A. The granuloma *per se* cannot be seen in a radiograph but the granuloma occupies an abnormal hole or cavity in the bone and this hole or cavity in the bone can be seen.

Q. Can infection be seen in radiographs?

A. Infection *per se* cannot be seen in radiographs. What we see is osseous structural change due to infection, i. e., evidence of infection.

Q. What is the appearance of a carious cavity in an X-ray negative?

A. A dark (radiolucent or radioparent) spot in the crown of a tooth.

Q. What is the appearance of a pulp stone in an X-ray negative?

A. A light (rather radiopaque) area in the dark of the pulp chamber or canal.

Q. Mention the more-or-less radiopaque things in a dental radiograph starting with the most radiopaque.

A. (1) Metal crowns, fillings and posts. (2) Enamel. (3) Dentin and cementum. (4) Bone, including lamina dura (dental lamella), and other cortical bone shadows. (5) Pulp stones.

Q. Mention some more-or-less radiolucent and radioparent things in a dental radiograph.

A. (1) Pulp chambers and canals. (2) The pericemental membrane line. (3) Marrow spaces in bone. (4) Decay spots in crowns of teeth. (5) Periapical abscess cavities. (6) Antrum. (7) Foramina.

Q. How is radiopacity registered on the X-ray negative, as a transparency or a dark area?

A. As a transparency.

Q. How is a radioparent area registered on a print made from an X-ray negative, as a light area or a dark area?

A. As a light area.

Q. What is the appearance of a print made from an X-ray negative compared to the X-ray negative?

A. The blacks and whites are reversed. That is to say what was dark in the negative is light on the print and what was light on the negative is dark on the print. For example, an abscess cavity is dark in the negative, light in the print; a metal filling is light in the negative, black in the print.

CHAPTER XVI

CLINICAL RADIODONTIA

Q. Is it very important that cavities be found (and filled) before they encroach upon or irritate the dental pulp?

A. Yes. This seems, to the writer, to be the most important thing in dentistry—to find cavities and fill and refill them and so prevent pulp disease and any chance for focal infection of the periapical type.

Q. Are radiographs useful to examine the mouth for dental caries?

A. Yes. Cavities will be found which would otherwise be overlooked, notably approximal cavities and recurrent decay at the cervical of old fillings.

Q. Do areas of periapical bone destruction vary much in size?

A. Yes, very much, from an area so small that it can scarcely be seen at the end of one root to an area so large that it involves several teeth.

Q. What is the meaning of the word osteoclasia?

A. Bone destruction or absorption.

Q. What is osteosclerosis?

A. Hardening of the bone.

Q. What causes osteosclerosis?

A. Osteosclerosis is found in the apical region of infected roots due to the stimulus of the irritant infection. Also about roots carrying bridges, due to mechanical stimulation. The writer looks upon the former as a protective effort on the part of Nature; and on the latter as a sort of effort to compensate for the added stress of mastication. The osteosclerosis about the roots of teeth with vital pulps carrying bridges seems to me to have no more pathologic significance than, as Hamilton puts it, "callous places on the laborer's hands."

Osteosclerosis may occur idiopathically; that is without any apparent cause at all. It occurs more frequently in the lower jaw than the upper.

Q. Does the size of the area of bone destruction ever govern the treatment indicated?

A. Yes.

Q. Name some means which are employed to cure periapical disease.

A. (1) Antiseptic treatment through canals. (2) Ionization. (3) Root resection and curettement. (4) Extraction.

Q. What is the appearance of an area of osteoclasia (bone destruction) in the X-ray negative and in the print?

A. Dark in the negative, light in the print.

Q. What are the local symptoms of periapical infection?

A. They vary greatly from those of an *acute* dento-alveolar abscess (swollen face, pain, sore tooth, loose tooth) to no local symptoms at all in chronic cases.

Q. Can evidence of an acute abscess be seen in a radiograph?

A. Yes, if there is bone destruction. No, if there is no bone destruction.

Q. Is a roughened root end a mechanical or bacterial irritant?

A. A roughened root end is a diseased, infected root end. The fact that it is mechanically rough is of secondary importance to this.

Q. How long does it take osteogenesis to take place in a medium size periapical abscess cavity?

A. 3 to 12 or 18 months, depending on size, character of treatment given, and health and age of patient.

Q. Can osseous infection persist, following removal of a tooth with periapical infection?

A. Yes, it is possible.

Q. How may periapical infection be eliminated at the time of extraction?

A. By "surgical extraction." Removal of the pyogenic membrane, and necrotic bone if present.

Q. Can a periapical granuloma—i. e. a pyogenic membrane—be seen in a raidograph?

A. No. But the abscess areas showing more or less smooth and symmetrical outlines are particularly likely to be granulomatous.

Q. When making an X-ray examination for unerupted teeth what may be found?

A. (1) The unerupted tooth in the jaw, but simply not erupted. (2) The unerupted tooth in malposition. (3) The unerupted tooth held

back from erupting by supernumerary teeth or an odontoma. (4) Absence of the tooth and in its place malformed tooth bodies—i. e., odontomata or supernumerary teeth. (5) Congenital absence of unerupted tooth and tooth bodies.

Q. In what direction does an unerupted tooth move?

A. In a general way it may be said that the tendency of an unerupted tooth is to move in the direction in which its crown points—i. e., in a line with its long axis. However an unerupted tooth *may* turn some to erupt, but it does not move backward to make a turn possible.

Q. What trouble may an unerupted tooth cause?

A. (1) Local suppuration. (2) Absorption of contiguous teeth. (3) Neuralgia and reflex pains in eyes, ears and head. (4) General nerve disorders, such as insommnia, neurasthenia and, according to neurologists, even insanity.

Q. Do all unerupted teeth cause trouble and should they all be removed?

A. No.

Q. What is an impacted tooth?

A. An impacted tooth is an unerupted or partially erupted tooth whose eruptive force has come in contact with some obstruction, usually another tooth.

Q. What tooth is most likely to be impacted?

A. The lower third molar. It becomes impacted between the second molar and the ramus. The upper cuspid and third molar are also frequently impacted.

Q. When the X-ray examination is for an unerupted upper cuspid or upper or lower third molar, is it likely that those teeth will be found in the jaw or congenitally missing from it?

A. In the jaw.

Q. When the X-ray examination is for other unerupted teeth than third molars and upper cuspids what are the probabilities of finding them?

A. The chances are a little in favor of congenital absence.

Q. Case: Root of permanent tooth absorbing. Tooth not a "planted" one. No unerupted tooth pressing against absorbing root. Root absorbing throughout its length. Pulp vital in some cases,

non-vital in others. No apparent cause for the absorption. What is the etiology?

A. The etiology of such cases is not clear. It *may be* syphilitic or traumatic. This writer has found such teeth in the mouths of syphilitics, also in the mouths of a football player and a pugilist.

Q. What is the meaning of peridontoclasia?

A. Literally peridontoclasia means: around tooth destruction. That is destruction of the tissues around a tooth. Pyorrhea is the common name for peridontoclasia. Periclasia is a contraction of the word peridontoclasia.

Q. What is the appearance of pyorrhea or peridontoclasia in X-ray negatives and prints?

A. Where the bone is lost the negative is dark (and so the print is light).

Q. Where does osteoclasia, due to pyorrhea, begin?

A. It begins in the cervical region and progresses toward the apical region.

Q. Is it true that bone destruction, due to pyorrhea, must be either on the mesial or distal of the roots of the teeth in order to be seen in radiographs.

A. In a broad, general way, yes. Yet the skilled radiodontist is able usually to discern osteoclasia on the facial or lingual, due to pyorrhea, in *good* radiographs.

Q. How do X-ray findings in pyorrhea, influence treatment and prognosis?

A. X-ray findings sometimes reveal pockets which the operator may have failed to find by instrumentation. Knowing the location and depth of the pockets, as revealed by radiographs, the operator is better able to curette the pockets and to decide regarding the expediency of the surgical removal of gum tissue to eliminate the pocket.

In a general way it may be stated that the amount of bone destroyed governs the advisability of treatment and the prognosis; the more bone lost the poorer the prognosis and the more radical the treatment indicated.

Stillman states that when the osteoclasia is on one side of the root only, that indicates "traumatic occlusion."

Q. Can one get osteogenesis and demonstrate it radiographically in cases of pyorrhea?

A. Yes, but it is more difficult and the new bone is more liable to disintegration than osteogenesis in the periapical region.

Q. What is the radiographic appearance of pulp stones?

A. Light areas in the pulp chamber and canals in negatives, dark areas in the pulp chamber and canals in radiographic prints.

Q. What trouble may pulp stones cause?

A. Neuralgia, toothache, death of the pulp.

Q. Are there many pulp stones which are causing no trouble?

A. Millions of them.

Q. What causes hypercementosis?

A. Probably a low grade of irritation (infectious or otherwise) amounting to a stimulation, causes hypercementosis; just as a low grade of infection will cause condensing osteitis, i. e., osteosclerosis.

Q. Is hypercementosis more common on pulpless teeth or teeth with vital pulps?

A. Much more common on pulpless teeth.

Q. Are pulpless teeth as a class easier or more difficult to extract than teeth with vital pulps?

A. More difficult, because of the tendency to hypercementosis and ankylosis.

Q. What is ankylosis?

A. True ankylosis is bony union in a joint. False ankylosis is immobility of a joint not due to bony union of the articulating surfaces.

Q. Give an example of true ankylosis.

A. A replanted tooth in the jaw and some pulpless teeth.

Q. Give an example of false ankylosis.

A. The temporo-mandibular joint in cases of acute inflammatory symptoms of impacted lower third molars.

Q. In cases of hypercementosis what particular warning should the patient receive before the tooth is extracted?

A. The patient should often be warned that it may be difficult to remove the tooth.

Q. How may radiographs help the pulp canal operator?

A. By showing the length and shape of roots and canals. By showing the operator when he is able to reach the apex with a diagnostic wire. By showing when the canal filling material reaches the apex.

Q. Should canal filling material reach just to the end of the root, fall just a little short of reaching the end of the root, or penetrate the end of the root ("encapsulate the root end")?

A. This is debatable. In pulpitis cases let us say the most perfect canal filling is one which reaches just to the cemento-dentin junction. (This gives Nature a chance to seal the apical foramina with "secondary cementum," or "osteoid tissue.")

In septic cases, let us say that the filling material should extend at least to the extreme apex if not penetrate it. (The evidence now at hand would seem to indicate that Nature does not fill the apical foramina with osteoid tissue in septic cases.)

Q. Which is the more desirable: to have some canal filling penetrating the end of the root or fall a little short of reaching the end of the root?

A. This is debatable. Perhaps it is arriving somewhere near the truth to say: In pulpitis cases, allow the canal filling to fall a little short of reaching the end of the root rather than force filling material through the end. In septic cases, let a little filling material go through the end of the root rather than have it not reach the end. (In pulpitis cases, the aseptic pulpectomy operation and canal filling only to the stub of the cut pulp is perhaps "the answer.")

Q. Which sort of cases are more likely to give post operative pain following canal filling, pulpitis cases or septic cases?

A. Pulpitis cases, especially if the canal filling material goes to the very end of the root or a little beyond.

Q. Is it possible, when the canal filling falls just a little short of the end of the root, that Nature will seal the apical foramina with osteoid tissue?

A. Recent research works seem to indicate that this occurs. (The evidence now at hand seems to indicate that perhaps this occurs only in pulpitis cases, not septic cases. In the septic cases the organ of generation—i. e., the pericementum which dips down into the foramina—is destroyed).

Q. When the tooth is a lower molar and some canal filling penetrates the end of the root, what important organ may the material impinge upon and with what results?

A. The inferior dental nerve, causing a great deal of pain.

Q. What is a tumor?

A. In a broad general way a tumor may be considered any abnormal growth. A wart (fibroma) for example. Hypercementosis (cementoma) for another example.

Q. What is an odontoma?

A. An odontoma is a tumor composed of tooth tissue, i. e., enamel, dentin and cementum.

Q. What is the radiographic appearance of an odontoma?

A. A more-or-less irregular mass, varying in size from about that of a pea to as large or larger than a hickory nut. In the negative the mass is light, in the print dark. The degree of radiopacity is the same as the teeth themselves, as would naturally be expected since the tumors are made up of tooth tissue.

Q. What are supernumerary teeth?

A. As the name implies, supernumerary teeth are extra teeth. They are extremely similar in nature to odontomata; in fact they are odontomata. The distinction between an odontoma and a supernumerary tooth is somewhat arbitrary. If the odontoma shows a moderately well-defined crown and root it is referred to as a supernumerary tooth; if its form is very irregular it is called an odontoma; if it is very small it is sometimes called a denticle.

Q. What form predominates in supernumerary teeth?

A. A sharp, cone-shaped crown and short root.

Q. In what regions are supernumerary teeth most often found?

A. Upper anterior, upper molar, lower bicuspid.

Q. What is a bone "whorl"?

A. A sort of benign osteoma, or, better, an osteosclerotic area. Radiographic appearance: a somewhat radiopaque area, average size about that of a small pea.

Q. Do bone "whorls" cause symptoms?

A. Some operators claim they may cause neuralgia. The writer grows more skeptical about accepting a bone "whorl" as a cause of

neuralgia. The removal of a bone "whorl" to cure neuralgia should be a sort of extreme resort, and the prognosis is at best very doubtful.

Q. What is a sequestrum?

A. A sequestrum is a piece of dead bone.

Q. What is the radiographic appearance of a sequestrum?

A. A piece of irregular bone separated from the main body of bone by the "line of demarcation" which appears as an irregular dark line in negatives and as a light line in prints.

Q. What is the radiographic appearance of a fracture?

A. An irregular break in continuity of the bone appearing dark in negatives, light in prints.

Q. Name some things which may be indicated by radiographic evidence of structural bone change.

A. (1) Pyogenic infection. (2) Syphilis. (3) Necrosis. (4) Osteoma. (5) Malignancy, i. e., cancer.

Q. What is the radiographic appearance of syphilitic bone?

A. Diffused radiolucency indicating bone destruction. Dark in negative, light in print.

Q. Can a diagnosis of syphilis be made from radiographs alone?

A. No. In cases of suspected syphilitic bone, a Wasserman test should be made.

Q. What is an osteoma?

A. A benign bone tumor.

Q. What are the symptoms of an osteoma?

A. Slow, painless enlargement of bone. Enlargement very hard; not tender.

Q. What is the radiographic appearance of an osteoma?

A. The normal sponge-like appearance of the bone is changed, the marrow spaces usually growing smaller.

Q. What is the radiographic appearance of a bone cancer?

A. Diffused areas of abnormal radiolucency; also sometimes areas of increased radiopacity.

Q. Can a diagnosis of bone cancer be made from radiographs alone?

A. No.

Q. Give a diagnosis for the following hypothetical case: Patient's age, 65. Recurrent severe pain on left side of face and jaw. Some tenderness in region of angle of jaw. Somewhat enlarged and tender lymphatic glands on left side under jaw and in axillary space. Wasserman negative. Pain gradually becoming more severe for last six months. Radiographic findings: Diffused areas of osteoporosity and osteosclerosis.

A. Tentative diagnosis of osteosarcoma pending microscopic examination.

Q. Name some foreign bodies which are sometimes found in and about the teeth and jaws.

A. Broaches in the teeth. Broken instruments and pieces of peeled-off nickel plating in alveoli and bone. Shot and such like in the bone and soft parts. Broken hypodermic needles in the soft tissues. Drainage tubes and pieces of tooth roots in the antrum.

Q. Can an orthodontic rubber elastic (or a ring of rubber dam left on the tooth by jerking the "dam" off carelessly) which has slipped under the free margin of the gum, be seen in a radiograph?

A. Sometimes; usually not, however.

Q. Does a piece of elastic rubber sliding rootwise cause any symptoms?

A. Yes, very severe symptoms. The tissues get highly inflamed, the tooth or teeth get loose and will be lost if the rubber is not removed.

Q. What is a cyst?

A. A cyst is a sack-like membrane together with its contents.

Q. Give an example of a physiological cyst.

A. The urinary bladder.

Q. What is a pathologic cyst?

A. A cyst representing disease as distinct from a physiological cyst which does not represent disease.

Q. What is a radicular cyst?

A. The word radicular refers to root, i. e., tooth root. A radicular cyst is one arising from a tooth root. Most cysts about the jaws are radicular cysts.

Q. What is the difference between a radicular cyst and a dento-alveolar abscess with a pyogenic membrane or sac?

A. The difference is somewhat arbitrarily considered to be that the cyst is larger and is lined with epithelial cells.

Q. What do pathologic cysts usually contain?

A. Serus fluid.

Q. What is a dentigerous cyst?

A. A cyst containing a tooth or tooth bodies.

Q. What is the radiographic appearance of a cyst in the jaw?

A. A dark (radiolucent) area in the negative, a light area in the print. The outline of the area is smooth, not jagged, and the shape somewhat circumscribed or oval. Size varies from that of a small hazel-nut to almost as large as an egg.

Q. What are the symptoms of a cyst in the jaw?

A. Slow, painless enlargement, until there may be considerable dis-figurement—then usually spoken of as a cystic tumor. If the bone over the cyst becomes thin enough it may feel "springy" on palpation. The outline of the enlargement is smooth, not jagged.

Q. What is the treatment for cysts?

A. Surgical removal by choice, or drainage.

Q. What is the prognosis for satisfactory recovery in cases of cysts?

A. In case of surgical removal, excellent. In case of surgical drain-age, fair or doubtful.

Q. Name some things which may cause neuralgia. Name them somewhat in the order of their importance.

A. (1) Pulpless teeth, particularly those showing periapical osteoc-lasia, highly imperfect canal fillings and hypercementosis. (2) Pulpitis caused by unsuspected cavities under the gum. (Such cavities are found with comparative ease and certainty by making a radiographic examina-tion.) (3) Unerupted teeth. (4) Antral empyema. (5) Syphilis. (6) Cancer. (7) Pulp stones. (8) Bone "whorls" (?).

Q. What is the radiographic appearance of an antrum filled with pus compared to one filled with air?

A. In the negative, the antrum filled with pus is light, while the one filled with air is dark. In the print, the antrum filled with pus is dark, while the one filled with air is light.

Q. Is there any difference in the radiographic appearance of an antrum filled with pus and one filled with polypi or other growths such as a cyst arising from an upper tooth?

A. Usually no. The radiograph only registers the presence of something filling the antrum. In cases of growths in the antrum however they may sometimes be seen to only partially fill the antrum.

Q. What are the symptoms of antral empyema?

A. Pain on affected side. Pain on leaning forward and downward. Eye disturbance on affected side. Pain when lying on affected side. Discharge of pus in nose, especially when lying on opposite side to that affected.

CHAPTER XVII

DIFFERENTIAL DIAGNOSIS AND MISTAKES IN INTERPRETATION

Q. How may one differentiate between the anterior palatine foramen and an area of periapical bone destruction due to infection?

A. By the use of the electric test for pulp vitality and by making radiographs at such an angle as to cast the shadow of the anterior palatine foramen (also called the incisive foramen) between the root ends of the central incisors (upper) instead of at the apex of one of them.

Q. Why is the electric test for pulp vitality of such great assistance in the interpretation of dental radiographs?

A. Because a tooth with a vital pulp cannot have that sequela of pulp death known commonly as "an abscess," i. e., a periapical disease characterized by localized infection and bone disintegration.

Q. Can the shadow of a periapical abscess cavity be cast away from the apex of the tooth and made to appear elsewhere on the radiograph?

A. No, if a periapical abscess cavity shows at all in a radiograph it will show at the root end of the affected tooth.

Q. Will an area of bone destruction arising from a root end always show in a radiograph, regardless of the X-ray angle at which the exposure was made?

A. No, in certain cases if the angle is wrong the existing area of bone destruction will fail to register in the radiograph.

Q. How may one differentiate between the mental foramen and an area of periapical bone destruction due to infection?

A. By the use of the electric test for pulp vitality and by casting the shadow of the foramen away from the apex of the tooth by changing the angle, or by making an extra-oral radiograph and locating the foramen elsewhere.

Q. At the apex of what teeth is the shadow of the mental foramen likely to fall?

A. The lower bicuspids, especially the second.

Figs. 40 and 41. There is a radiolucent area at the apex of the central incisor in Fig. 40 which might be mistaken for an abscess area *but the tooth responds positively to the electric test for pulp vitality.* Fig. 41 which was made from a different horizontal, i. e., mesio-distal, angle, shows this spot falling between the apices of the central incisors but not touching them. It is the anterior palatine foramen; also called the incisive foramen.

Figs. 42 and 43. Different views of the same case. The cuspid has the appearance of being involved in the large abscess (or cystic) area. But it responds to the electric test for pulp vitality. It has a vital pulp and is not involved. The electric test is necessary to correct radiographic interpretation in cases such as these as well as many other classes of cases. (From "Electro-Radiographic Diagnosis," reproduced here by courtesy of C. V. Mosby Co.)

Q. How may one differentiate between the antrum and cysts?

A. The electric test for pulp vitality. Also the antrum radiographic outline is less symmetrical and rimmed with thicker cortical bone shadows, i. e., light lines in the negative. The cystic enlargement can usually be seen by observation of the face or mouth unless it encroaches *into* the antrum.

Q. How may one differentiate between a cyst and a large area of bone destruction due to abscess or syphilis?

A. Differentiation by radiographic examination alone cannot always be made. However, it may be said that the cyst's radiographic outlines are distinct and smooth while the outline of the other lesions may be indistinct and jagged.

Q. A tooth, fully formed except the extreme apex, may be mistaken for what?

A. A tooth with a periapical abscess area.

Q. What causes indistinct root outlines in dental radiographs?

A. (1) Incorrect horizontal angle, i. e., mesio-lingual or disto-lingual angles, not straight lingually. (2) Absorption of the root surface. (3) Careless photographic technic. (Developer too warm). (4) The use of a tube with too broad a focal spot. (5) Hypercementosis.

Q. How may one differentiate between a small piece of metal and a small piece of gutta percha point?

A. The metal shows sharper outlines. Use a reading glass to study negatives.

Q. Does the radiograph always give a true indication of the exact size of an abscess cavity?

A. No. The radiograph lacks perspective, i. e., depth—and for this reason the operator may find the abscess cavity larger (deeper) than he expected.

Also an abscess hole in the external alveolar (facial) plate will be magnified, owing to the distance between the hole and the film, during exposure, and the divergence of the X-rays.

Q. How can one differentiate between an unfilled carious cavity and one filled with a silicate cement filling?

A. Silicate cement fillings are practically radioparent. Therefore it is usually impossible to differentiate radiographically between an unfilled cavity and one filled with silicious cement. Sometimes the cavity may show signs of having a more-or-less geometric form in the radio-

Fig. 44.

Figs. 44 to 48. An experimental case illustrating how a wrong vertical, i. e., vertico-horizontal, angle may result in failure of existing periapical bone destruction to register on the radiograph. (From *Dental Items of Interest,* December, 1919.)

Fig. 44. The skull from which Figs. 45, 46, 47 and 48 were made.

Fig. 45.

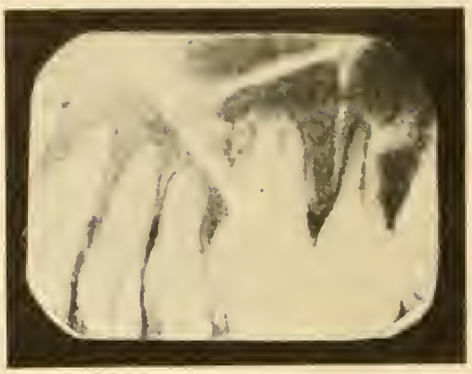


Fig. 46.

Fig. 47.

Fig. 48.

Fig. 45. Radiograph made at the correct vertical angle. The area of bone destruction registers.

Figs. 46 and 47. The films were in the same position as for Fig. 45 but the vertical angle was away higher and so the area of bone destruction does not register. (See Fig. 14).

Fig. 48. The film for this radiograph was placed flat, i. e., horizontal, in the mouth as illustrated in Fig. 44. The radiograph fails to register the bone destruction. Placing the film flat in the mouth necessitates a very high angle.

Fig. 49.

Fig. 50.

Fig. 51.

Fig. 52.

Figs. 49, 50 and 51. These radiographs, all of the same case, illustrate the fact that the best looking radiograph is not necessarily the best diagnostic radiograph. Figure 49 is the best looking radiograph, but it is so foreshortened (vertico-horizontal angle too high) that it does not show the area of periapical bone destruction. Figures 50 and 51 which are not so good looking do reveal the area of bone destruction.

Figure 50 is elongated (vertico-horizontal angle too low) and Fig. 51 is not very clear in root outline due to the horizontal angle at which it was made. Thus none of these three radiographs —Figs. 49, 50 or 51—were made at the correct angle. The bone destruction registers of course at the correct angle.

Fig. 52. Same case as Figs. 49, 50 and 51. This radiograph was made at the correct angle; both the vertico-horizontal and the mesio-distal angles were correct. (Figs. 49, 50, 51 and 52 are from the book "Electro-Radiographic Diagnosis" and are reproduced here by courtesy of the C. V. Mosby Co).

graph. This indicates that the cavity has at least been prepared for filling. And sometimes a slight shadow of silicate filling material may register on the negative. But the only sure way to determine whether a certain radiolucent spot in the crown of a tooth represents an open cavity or one filled with silicate cement, is to make an ocular or instrumental examination.

Q. How can one differentiate between (1) a vital pulp (2) a septic pulp (3) no pulp in the canals?

A. Pulpal tissue, vital or septic, is entirely radioparent so one cannot distinguish radiographically between a vital pulp, a septic pulp or the absence of pulpal tissue.

However, if the radiograph shows an area of periapical bone destruction, a dark streak in the negative representing the canal, and the tooth does not respond to the electric test, one may say with considerable certainty that the pulp is non-vital and septic.

On the other hand, if the pulp chamber and canals appear normally dark (i. e., radiolucent) in the negative and the tooth responds to the electric test for pulp vitality, one may say with much certainty that the pulp is vital.

Q. What roots may seem to be absorbed and to show periapical osteo-porosity in radiographs when conditions are normal and healthy?

A. Buccal roots of upper molars.

Q. Is it possible that a filling may have the radiographic appearance of entering the pulp chamber when it does not?

A. Yes. Especially proximo-occlusal fillings. This appearance is due to overlapping of the filling material and the pulp chamber, plus the fact that the radiograph is almost entirely lacking in perspective.

Q. Is it ever possible to determine from a radiograph that a filling penetrates the pulp chamber?

A. Not from the radiograph alone. But if, on ocular examination, a filling is seen to be near the center of the occlusal surface and not extending over on to any lateral surface, and the radiograph then shows that filling penetrating the pulp chamber, the operator may be reasonably certain that the filling material actually does enter the pulp chamber instead of lapping to the facial or lingual of it.

Q. Is it possible that a tooth which is not involved in a large dental abscess may have the radiographic appearance of being so

involved, and, if so, how may the fact that it is not involved be established?

A. Yes, it is possible that a tooth which is not involved in a large dental abscess may have the radiographic appearance of being involved. The establishment of the fact that the tooth under suspicion has a vital pulp indicates that it is not a contributing cause of the alveolar osteoclasia (the abscess). Conversely the establishment of the fact that the tooth under suspicion does not have a vital pulp indicates that it very probably is a contributing cause of the osteoclasia. The electric test is invaluable as a means of determining pulp vitality. If a tooth is not actually involved in an abscess but simply has the appearance of being so involved in a certain radiograph, it is sometimes possible, by changing the X-ray angle, to demonstrate *radiographically* that the tooth is not involved.

Q. How may one differentiate between pyorrhea and a periapical abscess?

A. Bone destruction due to pyorrhea starts in the cervical region and progresses apicalwise. Only a very advanced case reaches the apex of the roots.

Bone destruction due to periapical infection starts at the apex and may spread in any direction.

Establishment of the fact that the pulps of the teeth are not vital is contributing evidence of periapical infection.

Q. Can pus be seen in radiographs?

A. No, but bone dissolution incident to pus formation can be observed radiographically.

Q. Will radiographs reveal a *small* approximal decalcified spot of enamel before the enamel is lost and an actual cavity occurs?

A. Yes, the radiographic appearance being the same as though it were a cavity except for its very small size. The operator should look sharply to see if the decay has attacked the dentin. When only the enamel is attacked, filling is scarcely indicated at that time. The lesion should be kept under periodic radiographic examination.

CHAPTER XVIII

DENTAL INFECTION AND SYSTEMIC DISEASE

Q. What is infection?

A. "Infection is a condition of contamination with disease-producing bacteria and their noxious products."

Q. What is focal infection?

A. A spot of localized infection.

Q. What is metastatic infection?

A. Metastatic infection is infection which has been transmitted from an original focus to other parts of the body.

Q. Name some diseases that are said to be caused or aggravated by (focal) dental infection.

A. "Rheumatism" (arthritis), muscular rheumatism, neuritis, neruasthenia, endocarditis, myocarditis, anemia, gastritis, gastric ulcer, nephritis, cystitis, enteritis, acne, hyperthyroidism, headache, diseases of the eye, ear, sinuses and throat—in short, all diseases of doubtful or focal infectious origin.

Q. What is a metastatic disease?

A. A metastatic disease is one which has been transferred from one part of the body to another. For example, if infection has been transferred from the apex of a tooth to a joint, causing arthritis, the arthritis is a metastatic disease.

Q. What condition about the tooth may cause metastatic infectious disease?

A. (1) Periapical infection (i. e., dental abscess). (2) Peridontoclasia (i. e., pyorrhea). (3) Suppuration due to impacted, malposed teeth.

Q. What other things besides infection about the teeth may cause metastatic infectious diseases?

A. Gonorrhea, syphilis, suppurative sinusitis, chronic appendicitis, pus in the tonsils, pus in the prostate or Fallopian tubes.

Q. Where the examination of the mouth is to learn the status of the mouth as a factor in health (to see if there is any infection in the jaws, in other words), in what three general ways may the examination be conducted?

A. (1) By radiographing all parts of the mouth. (2) By radiographing all suspicious areas. (3) By radiographing "only the pulpless teeth" and shell crowned teeth.

Radiographs of all parts of the mouth should include a good radiographic view of all the teeth. Also the regions from which teeth are missing to see if there are any unerupted teeth or pieces of tooth roots, odontomata or like findings.

Radiographs of the suspicious areas include (a) all teeth judged to be pulpless (b) all shell crowned teeth (c) all teeth thought to be affected with pyorrhea to observe the extent of bone destruction (d) all regions from which teeth are missing.

Radiographs of only the pulpless and shell crowned teeth include only the teeth which cannot be tested or do not respond positive to the electric test for pulp vitality.

Q. How may the operator best judge as to the vitality or non-vitality of dental pulps?

A. By the use of the electric test.

Q. Can shell crowned teeth be tested with the electric test?

A. No. The reaction is always positive strong (+s) whether the pulp is vital or not.

Q. When the X-ray examination is not to include all parts of the mouth, is the use of the electric test for pulp vitality particularly indicated?

A. Yes, otherwise the matter of selecting the pulpless teeth is particularly hazardous, as a tooth which looks "all right" and has only a small filling, or no filling at all, may be pulpless.

Q. Where all parts of the mouth are radiographed, is it necessary to use the electric test for pulp vitality?

A. The writer very often finds it necessary, to assist in interpretation. Radiographs alone or the test alone may be misleading, but taken together the chance for mistake is reduced to the minimum.

Q. When there is still doubt about the vitality of a pulp after both radiographs and tests have been made, what may be done?

A. Make a diagnostic opening into the tooth of sufficient distance to learn if the pulp is vital.

Q. Can one see periapical infection in radiographs?

A. No. One can see only evidence of infection in radiographs.

Q. What things, which may be seen in radiographs, may be looked upon as evidence of infection? Name somewhat in order of importance.

A. (1) Osteoclasia. (2) Imperfect canal filling. (3) Osteosclerosis. (4) Hypercementosis.

Q. What is osteoclasia?

A. Osteoclasia is bone destruction. It is by far the most important evidence of infection that one sees in radiographs.

Q. What sort of infection is represented by imperfect canal fillings?

A. Intra-dental infection. And intra-dental infection may be considered potential periapical infection. This, providing the apical foramina are not sealed with osteoid tissue.

Q. What is osteosclerosis?

A. Hardening of the bone. Osteosclerosis is of much less importance as evidence of infection than osteoclasia.

Q. What is hypercementosis?

A. Hypercementosis is hypertrophy, or excessive growth of cementum on the root of a tooth. Like osteosclerosis it is much less important as evidence of infection than osteoclasia.

Q. How may pulpless teeth be classified?

A. According to (1) evidence of periapical infection, (2) evidence of intra-dental infection, (3) history of pulp disease, (4) history of surgical nature of treatment given.

Q. Give a classification of pulpless teeth according to the evidence of periapical infection.

A. Pulpless teeth may be classified into 4 classes according to the evidence of periapical infection as follows: Those showing

(1) Definite evidence of periapical infection.

(2) Less definite (or somewhat indefinite) evidence of periapical infection.

(3) Questionable evidence of periapical infection.

(4) No evidence of periapical infection.

Q. Give a classification of pulpless teeth according to the evidence of intra-dental infection.

A. Pulpless teeth may be arbitrarily classified according to the evidence of intra-dental infection into 5 classes as follows: Those showing:

(1) Open canal. (2) A very short canal filling but open canal cannot be seen clearly.* (3) Fair canal filling. (4) Good canal filling. (5) Apparently perfect canal filling.

Q. Give a classification of pulpless teeth according to the history of the disease prior to treatment and canal filling.

A. Pulpless teeth may be classified according to disease before treatment into 3 classes as follows: (1) Those giving a history of sepsis; (2) those in which the history is unknown; (3) and those giving a history of pulpitis.

Q. Give a classification of pulpless teeth according to the history of the treatment given the tooth.

A. Pulpless teeth may be classified acccording to the treatment given them into 3 classes as follows: (1) Those in which the nature of the treatment given is unknown; (2) those in which the treatment was antiseptic; (3) and those in which the treatment given was in accord with the rules of aseptic surgery.

Q. Are pulpless teeth risks to health?

A. All pulpless teeth are risks to health. The risk may be negligible or it may be great.

Q. Which is more important and reliable: positive periapical findings or negative periapical findings?

A. Radiodontic periapical findings are something like the findings from a Wasserman test. A positive finding leaves little or no doubt but a negative finding may leave some doubt.

Q. Are disease and bacterial infection the same thing?

A. No. Bacterial infection means simply contamination with disease-producing bacteria and their products. We may have a condition of bacterial infection without having disease present just as we may have

* If the history is of a case of pulpitis, and the case was treated years ago, and there is no evidence of periapical infection the open canal may contain vital pulpal tissue instead of septic matter.

seeds in the ground without getting a growth from them. As an example of bacterial infection without disease, consider tuberculosis. The lungs of no civilized man escape infection by the tubercle bacilli. More, it is probably safe to say that the lungs of civilized man are almost constantly infected with tubercle bacilli. Yet everybody does not have the disease as a result of this bacterial infection. Broadly speaking, the infection with the bacteria is always present but infection with the disease occurs in only about 10%.

We may have bacterial infection without disease and disease without bacterial infection. (All diseases are not infectious. For example, some are nutritional). Even though this is true, infection with pathogenic bacteria, and disease are very closely related. And elimination of bacterial infection is often a prerequisite to cure.*

Q. What is the nature of the infection found at the apices of roots of teeth?

A. Streptococcic (streptococcus hemolyticus, streptococcus viridans) and staphylococci.

Q. Differentiate between disease and infection in the case of a dental abscess.

A. The infection means the contamination with bacteria, the disease is the destruction of tissue, osseous and otherwise.

Q. Can an abscessed tooth showing an area of bone destruction be treated in such manner that new bone will grow back in the abscess cavity?

A. Yes.

* There are other kinds of infection besides bacterial infection. One may be infected with a non-bacterial disease, or with joy or enthusiasm for that matter. Judging from the manner in which men use the word infection, I should say they very frequently mean simply contamination with disease-producing bacteria and their products. For example the phrase "infected instrument" could mean nothing more. However when one speaks of an infected tooth or an infected wound one usually means infected with bacteria *and* disease. By disease I mean pathologic, destructive tissue change. Again, investigators who have recovered bacteria from the new bone built in periapical abscess cavities have said that they have found "infection" in the new bone. They have found infection with bacteria; they have not found infection with disease, that is, pathogenic destructive tissue change. In fact the presence of the new bone is evidence of construction, not destruction. In brief, infection may be defined as (1) contamination with disease-producing bacteria and their noxious products (2) contamination with disease-producing bacteria and their noxious products with co-existing consequent pathologic change. As the word is used in medical and dental writings one is often compelled to deduce from the context, or guess at, just what the writer means.

Q. Does ostogenesis prove absence of infection?

A. No, not necessarily.

Q. What is osteogenesis?

A. Generation or production of bone.

Q. Name some things which should be taken into consideration when deciding for or against extraction of pulpless teeth.

A. (1) The X-ray findings and history, i. e., (a) evidence of periapical infection (b) evidence of intra-dental infection (c) history of disease (d) history of treatment. (2) The number of pulpless teeth. (3) The location of the pulpless teeth. (4) The possibility or impossibility of making a satisfactory prosthetic appliance after extraction. (5) The patient's attitude toward treatment and ability to pay for it. (7) The patient's state of health. (This last is not placed last because it is the least important but because it is often the *deciding factor* after all other details are considered).

Q. How important are the X-ray periapical findings as a means of determining extraction of pulpless teeth?

A. The most important, except in cases where the state of the patient's health makes it imperative that *all risk* of dental infection be eliminated, in which event the operator or medical internist may deem it necessary to extract all pulpless teeth regardless of X-ray periapical findings.

Q. How may the number of pulpless teeth govern extraction?

A. Let us take a concrete case for example. There is only one pulpless tooth, a second molar, showing no evidence of periapical infection, fair canal fillings, history of tooth disease and the kind of treatment given unknown. Patient a young lady of 23 suffering from acne. No apparent cause for acne except the pulpless tooth. It is rather improbable that the pulpless tooth is causing the acne, but it may be a contributing factor and it costs the patient *only one tooth* (the pulpless tooth) to eliminate the mouth and teeth as a *possible* cause, contributory or otherwise.

Under such circumstances it seems to the writer it is expedient to sacrifice the tooth.

Q. How may the location of pulpless teeth govern extraction?

A. Certain pulpless teeth in certain cases may be said to occupy strategic positions, so that for example the removal of one particular tooth would alter completely the nature and efficiency of the restorative prosthetic appliance to be made later. Thus some particular efforts may be exerted to retain such teeth.

The cuspid teeth both above and below are particularly important teeth because of their prominent position at the turn of the dental arch.

Q. How may consideration of the prosthetic appliance to be made govern extraction?

A. One would have less hesitancy about extraction where the problem of making a satisfactory prosthetic appliance is simple than though it were particularly complicated.

Q. How may the patient's attitude toward extraction govern extraction?

A. There are some cases where the teeth are so obviously a menace to health that the patient's attitude toward extraction should not influence the operator. On the other hand there are other cases where it is exceedingly problematic if the teeth are or are not exerting an untoward systemic effect. In such cases the patient, it seems to me, is very clearly entitled to special consideration of his desires. All pulpless teeth are risks. If a patient cares little or nothing about the loss of teeth it is folly for an operator to insist on trying to save pulpless teeth.

On the other hand some patients will say they "would rather die than lose their teeth" and they *almost* mean it. The loss of teeth to them is a most serious, tragic matter. If there is a "reasonable doubt" such people should be given the benefit of such doubt.

Retention of pulpless teeth often means their special treatment. This treatment is most difficult and expensive and requires a great deal of patience on the part of both operator and patient. It may be done in selected cases for people who will coöperate, who want it badly enough; but not for others.

Q. Case: Many pulpless teeth. Large portion of them showing periapical bone destruction. In a broad general way what does this indicate?

A. Susceptibility of patient to dental infection.

Q. Case: Many pulpless teeth. Only one or two or none showing periapical bone destruction. In a broad general way what does this indicate?

A. Relatively high degree of immunity to dental infection.

Q. Which is more dangerous, swallowing pus or absorbing pus?

A. Absorbing pus. (The gastric juice is bactericidal).

Q. Which is more dangerous to health, a loose tooth with periapical infection or a tight tooth with periapical infection?

A. Duke says the loose tooth because it acts as a pump, when bitten upon, forcing infection into the tissues and so increasing absorption.

Q. How does general health influence extraction of pulpless teeth?

A. If the general health is very bad, radical extraction is indicated unless there are other obvious causes for the ill health. Where X-ray findings are doubtful, the state of the patient's health may govern to a great extent how radical the operator should be in his extraction. The healthier the patient the less radical.

Q. The patient's health may be learned by consideration of the health pictures, namely the ordinary health picture and the special health picture. What is the ordinary health picture?

A. The *ordinary health picture* may be ascertained by eliciting answers to such questions as the following: (1) How is your appetite? (2) Can you eat whatever you want without distress? (3) Do you take cathartics often? (4) How do you sleep? (5) How do you feel, good, bad, restless, nervous, sick? Etc.

Q. What is the special health picture?

A. The *special health picture* can be ascertained by learning (1) the pulse (2) the temperature (3) the hemoglobin index (4) the blood pressure (5) the blood examination (6) the urine examination. Etc.

Q. What is the normal pulse?

A. 72.

Q. Is 72 the normal pulse for all people?

A. No, some people have a pulse which normally may go some above or below 72. Seventy-two is the *average* normal.

Q. What is the average normal sublingual temperature?

A. Ninety-eight and six tenths degrees (98.6) Fahrenheit. (Some authorities * give a range of normal temperature as within the boundaries of 97.2 and 99.5).

Q. Is it extremely unusual for a healthy person to have a subnormal temperature?

A. No. In the morning, most people have a temperature below normal, i. e., a temperature below 98.6.

* Butler's "Diagnostics."

Q. Is a temperature above normal a danger signal?

A. It usually is. A temperature above normal calls for a medical investigation for some pathologic lesion.

Q. What is meant when it is said that a patient has a fever or pyrexia?

A. That the body temperature is above normal.

Q. Give chart † of febrile temperatures.

A. Sub febrile 99.5 to 100.5.
Slight fever 100.5 to 101.5
Moderate fever 101.5 to 103
High fever 103 to 105
Hyperpyrexia 106 or above.

Q. Can a temperature of 99° be caused by very hot weather?

A. Yes.

Q. How much may chronic dental infection raise the body temperature?

A. About a degree. (Under certain conditions such as imprudent extraction for example the temperature may be raised a great deal).

Q. How much may acute dental infection raise the body temperature?

A. About a degree, or more.

Q. What is meant by the rather loose phrase "the patient has a temperature"?

A. What is meant is that the patient has a fever, i. e., a temperature above normal.

Q. What is the hemoglobin index?

A. An index of the amount of hemoglobin (iron) in the red blood corpuscles; hence it is an indication of oxygen-carrying power of the blood.

Q. What is the normal hemoglobin index?

A. From 100 downward to 85. (When the hemoglobin index is below 85 it is well to make a blood count of the red cells to learn if the patient has anemia).

† Butler's "Diagnostics."

Q. When a patient has anemia what should be the general attitude toward elimination of mouth infection?

A. Rather radical, if approved by the attending physician.

Q. What is blood pressure and how measured?

A. The "blood pressure" is the pressure of the blood in the arteries and is measured by a device known as the sphygmomanometer.

Q. What is systolic blood pressure?

A. Systolic blood pressure is the pressure of the blood in the arteries while the heart ventricles are contracted.

Q. What is diastolic blood pressure?

A. Diastolic blood pressure is the pressure of the blood against the artery walls while the heart ventricles are dilated.

Q. Which is the more important for general diagnostic purposes, systolic or diastolic blood pressure?

A. Systolic.

Q. What is the average normal systolic blood pressure?

A. The average normal systolic blood pressure varies with age and may be estimated by adding the patient's age to 100. Thus if the patient were 40 years old, the normal systolic blood pressure would be about 140.

Q. What is the significance of a high blood pressure?

A. Fundamentally a high blood pressure indicates "hardening of the arterial walls," or vasoconstriction. The arterial walls get hard with age. Bright's disease, i. e., kidney (disease) disintegration, is attended with a high blood pressure.

Q. Give a list of some things which cause a high blood pressure.

A. A list of things causing high blood pressure follows: (1) Pain. (2) Chronic interstitial nephritis (i. e., chronic Bright's disease). (3) Arterial sclerosis (produced by age and "high living"). (4) Acute peritonitis. (5) Ether. (6) Syphilis. (7) Toxic conditions such as lead poisoning, uremia, goiter and *focal infections*. (8) Nitrous oxid. (9) High altitudes. (10) Fear and excitement.

Q. What is the significance of a low blood pressure?

A. Fundamentally a low blood pressure indicates a vasodilatation.

Q. Give a list of things which cause a low blood pressure.

A. (1) Exhaustion. (2) Wasting disease such as tuberculosis.

(3) Some acute infectious diseases. (4) Hemorrhage. (5) Shock and collapse. (6) Chloroform.

Q. When a patient has an abnormally high or low blood pressure, what bearing does this have on the necessity of eliminating mouth infection?

A. If the physician, having charge of the case, is at a loss to explain the cause of the abnormal blood pressure, the dental treatment, calculated to eliminate mouth infection, may be more radical if such a course is approved by the medical internist having charge of the case.

Q. What is meant by a "white count of 8000"?

A. It means that the count of the white blood cells is 8000, i. e., there are 8000 white blood corpuscles in one cubic millimeter of blood.

Q. What is the normal "white blood count" or leukocyte count?

A. From about 6500 to 8500. The average normal count is about 7500.

Q. What is leukocytosis?

A. An increase in the number of white blood cells. A count of 10,000 or more indicates leukocytosis. Ten thousand is a *very slight* leukocytosis; it is, one may say, "the beginning of leukocytosis." In severe cases of acute infection the leukocyte count may go up to as high as forty to fifty thousand; in cases of acute appendicitis for example. In rare cases it may go up to 100,000.

Q. What is leukopenia?

A. A decrease in the number of white blood cells. A count of 5000 or less indicates leukopenia. A count of 5000 is the beginning of leukopenia.

Q. Give examples of things besides disease which cause a variation in the number of white blood cells.

A. The following things cause a raise in the leukocyte count: (1) Pregnancy. (2) Exercise. (3) Cold baths. (4) Eating. (There is a raise in the leukocyte count after meals).

The following things cause a decrease in the leukocyte count: (1) Hot baths. (2) Exhaustion. (3) Starvation and malnutrition.

Q. Name some diseases which cause leukocytosis.

A. (1) All acute inflammatory disease (abscesses, pleurisy, peritonitis, appendicitis, dermatitis). (2) Acute infectious diseases (ery-

sipelas, pneumonia, mumps, scarlet fever, rheumatic fever, meningitis, diphtheria, etc).

Q. Name some diseases which cause leukopenia.

A. (1) Spanish influenza. (2) Typhoid fever. (3) Measles. (4) Malaria. (5) Pernicious and splenic anemia.

Q. What is leukemia?

A. A very serious disease, one of the signs of which is a continued leukocytosis.

Q. Where there is leukocytosis or leukopenia without apparent cause or where mouth infection may be contributory to the cause, what effect should this have on the dental operator's decision about extraction?

A. It should make the operator more radical about the elimination of mouth infection. The dental operator should consult with the attending physician freely in such cases and be governed largely by his advice.

Q. What is the Arneth blood count?

A. It is a method of estimating the age of white blood cells. It is presumed that if the white cells attain their normal age the resistance of the patient is high or normal, but if the white cells die too soon it is taken as an indication that the patient does not have a high resistance to infection. Therefore it may be said that the Arneth count is an index to the patient's resistance to infectious disease.

Q. What is the normal Arneth blood count?

A. The normal Arneth blood count is indicated by the figures 65/35. The sum of 65 and 35 is 100. The figures of an Arneth added always equal 100 and is based on the counting of 100 cells.

Suppose the Arneth is 85/15. Such an Arneth is one which "shifts to the left."

Shifting to the left is indicative of lowered resistance.

Q. How does the Arneth blood count influence extraction of pulpless and pyorrhea teeth?

A. A patient with an Arneth count shifting to the left should not be allowed to take as much risk from dental infection as others. (Consult with the attending physician).

Q. Name the 3 most important kinds of white blood cells or leukocytes, and tell in what proportion they occur in normal blood.

A. Polymorphonuclear neutrophiles ..... 65 to 70%

Small lymphocytes	12 to 20%
Large lymphocytes	5 to 10%

Q. What is the literal meaning of the name polymorphonuclear neutrophile?

A. *Poly*, many. *Morpho*, form. *Nuclear* refers to nucleus. A neutrophile is a cell which can be stained with a neutral dye. Therefore polymorphonuclear neutrophiles are white blood cells with multiple nuclei of various forms and which can be stained with a neutral dye. For convenience the name polymorphonuclear is contracted to polynuclear and polymorphonuclear neutrophiles are commonly referred to as "polynuclears," or "poly cells," or "polys."

Q. From the viewpoint of the pathologist what may be said of the polymorphonuclear neutrophiles?

A. This type white blood cells (leukocytes) normally constitute the greater proportion of leukocytes. Poly cells are active phagocytes. That is to say they are the active enemies of bacteria, having the power to ingest and destroy them. *Acute* pyogenic infection increases the number of poly cells. That is to say we get an "increase of the polynuclears."

Q. From the viewpoint of the pathologist, what may be said of lymphocytes?

A. "These cells do not increase to any great extent in cases of acute inflammation and infection but they are commonly associated with chronic and sub-acute lesions such as are present in tuberculosis, syphilis *" and, according to some, dental infection and other chronic local foci. It is presumed that the rôle they play in chronic infection is a combative or defensive one.

Q. In a general way how may we look upon the phenomenon of lymphocytosis?

A. As a response on the part of Nature to a call for a defensive army to combat infection.

Q. In a general way how may we look upon the phenomenon of a decrease in the number of lymphocytes?

A. As a failure on the part of Nature to respond to a call for troops to combat an invading army of infection. Therefore a diminution in the number of lymphocytes is a bad prognostic sign. This sign occurs in Spanish influenza; the lymphocytes are overwhelmed by the infection.

* Guthrie McConnell M.D., Cleveland. From report Research Institute N. D. A.

Q. What change, if any, occurs in the blood picture 24 to 72 hours after the extraction of an infected tooth?

A. Often an increase in poly cells.

Q. Does any particular blood picture indicate dental (or other) focal infection?

A. Reporting on records of 100 cases Daland* says: "Small cell lymphocytosis with a corresponding decrease in polymorphonuclear cells is an important diagnostic sign of periapical dental infection, the value of which is increased when leukopenia co-exists."

Q. Where does lymphocytosis begin?

A. At about 38%. (Both small and large lymphocytes taken together).

Q. Where does abnormal decrease in poly cells commence?

A. At about 60%.

Q. Where does abnormal increase in poly cells commence?

A. At about 80%.

Q. What is the difference between relative and absolute lymphocytosis?

A. Suppose the per cent. of lymphocytes is 50%. This indicates a lymphocytosis. But suppose also that there is a co-existing leukopenia, so that, though the proportion or per cent. of lymphocytes, compared to the other white cells is above normal, there are in actual numbers no more or fewer lymphocytes even than in normal blood. Such a lymphocytosis is *relative,* not *absolute.* Ordinarily when speaking of lymphocytosis we mean *either* relative or absolute.

Q. What is the complement fixation test?

A. The complement fixation test is a blood test. It is a means of determining if there are antibodies in the blood. The presence of bodies which are antagonistic to certain kinds of infection indicate the presence of that particular kind of infection.

The Wasserman test for syphilis is a complement fixation test.

The complement fixation test has also been applied to test for tuberculous infection and streptococcic infection but without much success thus far.

Q. What is the agglutination test?

A. The agglutination test is a blood test to determine the presence or absence of agglutinins in the blood.

* Journal of the American Medical Association Oct. 22, 1921.

The Widal test for typhoid fever is an agglutination test. Technic: Some typhoid bacilli are mixed with blood serum of the patient suspected of having typhoid fever and observed in a hanging drop under the microscope.* If agglutinins (a kind of antibody) are present they cause the bacteria to clump or group together.

Presence of agglutinins is taken as evidence of existence of the disease.

The agglutination test may be applied to test for streptococcic infection. It has not been developed to the point of recognized clinical value for dental cases.

Q. What is the (bacterial) protein sensitization test?

A. A skin test to determine especial sensitivity to certain bacterial infections. For example, the diagnostic tuberculin skin test. The method has been suggested to diagnose dental infection, but as yet has not been developed to the point of practical clinical value.

Q. Which is more pathogenic, staphlycoccic or streptococcic infection?

A. Streptococcic. Some kinds of staphlycoccic infection are *almost* non-pathogenic.

Q. What is the present status and future possibilities of the complement fixation test, the agglutination test and the protein sensitization test as means of determining existence or non-existence of dental infection?

A. None of these tests can be used to-day with much satisfaction as a means of determining dental infection.

The complement fixation test is so laborious that, considering also its inaccurate results, it seems to give little promise of becoming useful or popular.

The agglutination test perhaps holds some undeveloped possibilities as a means of determining dental infection where the radiographic evidence of infection is doubtful.

The protein skin test for dental infection may hold some possibilities but it also is in a state of undevelopment.

Q. What does a positive complement fixation or agglutination test indicate?

A. A positive complement fixation or agglutination test for streptococcus indicates that streptococcic infection is having a blood effect.

However it does not prove that the infection is of dental origin (may

* A "Macroscopic Agglutination Method" is described by Gates, Journal A. M. A. December 24, 1921.

be tonsils, Fallopian tubes, etc.) unless the bacteria used in the test are autogeneously dental—i. e., taken from the teeth.

Q. How do the complement fixation test and agglutination test compare to the Arneth blood count as an aid in determining metadstatic dental infection and what to do about it? In other words, which has the greatest diagnostic value?

A. The Arneth count.

Q. When urinälysis shows albumin and casts what does this indicate?

A. It indicates nephritis, i. e., inflammation, and therefore a variable amount of degeneration, of the kidneys. Nephritis may be due to a low grade chronic infection, dental or otherwise.

Q. How does the presence of nephritis influence dental treatment?

A. The operator should be more radical in his efforts to eliminate infection. (Consult with the attending physician).

Q. What bearing, if any, has the presence of sugar in the urine on tooth extraction?

A. Duke advises that particular care should be exercised in the extraction of teeth for diabetics. He advises that the patient should be rendered "sugar free," by suitable treatment, before any extraction is done, except when the case is of an urgent, emergency nature. He advises serial extraction, removing not more than three teeth at a time and at intervals of 1 to 3 weeks, depending on how the patient reacts.

Q. Let us imagine the following case: The ordinary health picture is good; that is to say the patient eats well, sleeps well, feels well, etc. Also the special health picture is good; that is to say the pulse, temperature, blood pressure, blood picture and urine analysis are normal (or if in any way abnormal the abnormality can be fully explained without consideration of the mouth as a cause or contributing cause). What should be the general attitude toward elimination of mouth infection?

A. Obvious infection should be eliminated, but the general principle of treatment should be *conservative* (conservative as opposed to radical extraction).

Q. How may the teeth cause headache?

A. (1) By nerve irritation which is rather direct and due to such lesions as impacted teeth. (2) By metastatic infection.

Q. What other things besides the teeth may cause headache?

A. Eye disturbances, sinusitis, constipation, nephritis, etc.

Q. How may teeth cause eye and ear disturbances?

A. (1) By referred nerve irritation such as impacted teeth and (2) by metastatic infection.

Q. How may the family history influence the dental treatment?

A. Definite history of rheumatism, heart disease, nephritis, etc.—i. e., streptomycosis—indicates more radical treatment to eliminate possible infection.

Q. Is it possible for infection to exist in the jaw bone after the extraction of the infected pulpless tooth?

A. Yes, it is *possible*, but the writer seldom is able to see the evidence of infection that others profess to see in radiographs of such regions.

Q. What is the prophylactic significance of secondary dentin and why is it of special interest to dentists?

A. Secondary dentin may be looked upon as an effort on the part of Nature to prevent exposure of the dental pulp. The solution of the problem of pulpless teeth rests on the formation of secondary dentin. If patients and dentists will co-operate and fill and refill cavities as fast as they occur, Nature will do her share by throwing up a protection of secondary dentin thus causing the pulp to recede to a point of greater safety so, as the recurrence of decay necessitates larger fillings, such fillings may be inserted without encroaching on the pulp.

Q. What is the prophylactic significance of hypercementosis?

A. Hypercementosis usually occurs on pulpless teeth. It may be looked upon as an effort on the part of Nature to seal any existing infection in the canal of a tooth, to keep it from passing into the periapical tissues.

Q What is the prophylactic significance of a rim of osteosclerotic bone surrounding a spot of osteoclasia at the apex of the root of a tooth?

A. The rim of osteosclerotic bone surrounding a dento-alveolar abscess cavity may be looked upon as an effort on the part of Nature to "wall off" the infection, to keep it local, to prevent systemic dissemination.

Q. What is meant by serial extraction?

A. The taking out of one, two or three teeth at a time, where there are a number of teeth to be extracted, at intervals of 8 to 16 days.

About 8 days if the patient is not very ill, about 16 days if the patient is quite ill.

Q. What is allergy? (Spelled also allergia and allergie).

A. The literal meaning of the word allergy is "another energy." Two definitions are quoted here:

Allergy is "a condition of altered susceptibility which causes an individual to react to a secondary innoculation of an antigen in a manner different from his reaction to the first innoculation." *

Allergy is "the condition of an infected organism toward a reinfection by the primary infection, or its reaction toward the toxin of that infective agent. An allergy may be in line with hypersensitivity, anaphylaxis, or of immunity." †

Q. What is anaphylaxis?

A. Anaphylaxis is "a state of excessive susceptibility to the action of a toxin or a drug after repeated injections or use." †

Q. Why is serial extraction expedient?

A. If the teeth are causing systemic disease their removal may cause exacerbation of symptoms, i. e., an allergic reaction. If a great number of teeth are extracted at one time the exacerbation of symptoms may be great enough to prove serious or even fatal.

Serial extraction avoids danger of a severe reaction, and, by giving a series of small reactions, has a curative action similar to the administration of a bacterine.

When in doubt as to whether the teeth are causing the systemic disease, serial extraction enables the operator to watch for reactions. The occurrence of reactions indicates a relationship between the teeth and the systemic disease.

Q. Which is to be preferred, removing a large number of infected teeth at one operation, or 1 to 3 teeth every 2 or 3 days?

A. Looking upon the procedure of removing a large number of infected teeth at one time as one which may produce a serious allergic reaction, Duke calls attention to the fact that it is nevertheless better to remove all infected teeth at one operation than to remove 1 to 3 teeth every 2 or 3 days. When the intervals between extractions are only 2 or 3 days instead of 8 to 16 days (or longer) the patient does not have time to recover between reactions and there is danger of severe shock.

* By Von Tirquet, from Dorland.

† Appleton.

(How dangerous it is to take out a great number of infected teeth at one time depends a great deal on how the operation is done).

Q. Is there any objection to currettement following extraction of teeth with periapical infection?

A. None that the writer can see *if it is not needlessly radical;* and, in some cases, it is imperative. There should be currettement enough to remove the pyogenic membrane and necrotic bone. Vigorous scraping of vital bone "because it is infected" seems to me to be a mistake.

Q. When teeth are treated and canal work is done, what may be done to reduce the risk, of the tooth to health, to the minimum?

A. Practice surgical asepsis, "check" canal filling with radiographs. Keep under periodic radiographic observation.

Q. When should pulpless teeth be extracted and when may they be retained?

A. Pulpless teeth which show radiographic evidence of bone destruction should either be extracted or treated in such manner that subsequent radiographs demonstrate bone regeneration. When to treat and when to extract depends on many details such as, the particular tooth involved, the extent of the local disease, the patient's wishes, the patient's ability to pay for modern aseptic treatment, the patient's state of health, etc., etc.

When pulpless teeth show no radiographic evidence of periapical disease, there is no reason for extraction then so far as local conditions are concerned. (For convenience, I do not here consider such special reasons for extraction as pyorrhea, fracture, perforations, etc.). If they are to be extracted at all then it is because they are risks to health; in short, the state of general health governs their extraction. The patient's health may be such as to indicate the extraction of every pulpless tooth, or it may not.

In this connection permit me to quote a part of my answer to a question similar to the one above, in the Elmer S. Best Questionnaire, published by the Journal of Dental Research:

". . . the final matter of determining what to do is usually more than a one-man-job. Dentists should consult with one another, with dental diagnosticians, and also with medical internists. When there are no local reasons for extracting teeth, the medical internist's opinion should carry very great weight. As dentists, we need all the assistance we can get from the medical internist; to be more accurate *we need more than we can get*, 'if you get what I mean.' I look upon all pulpless teeth as risks, but then I know life is full of risks, and that all living persons

must take risks. It is a risk to cross a street—a Ford may hit you. The question is not: 'are pulpless teeth a risk?' but 'how great a risk are they?' and is the patient justified in taking the risk, or should it be removed? To determine this, we must not only take into account local conditions and indications, but also the health picture, the common-sense health picture, including how the patient eats, feels, sleeps; his weight, pulse, temperature, etc.; also the laboratory health picture including the urine analysis, the blood picture, etc. There is no easy way of determining when to extract pulpless teeth. There is nothing to take the place of intelligent mental activity exerted and applied in each specific case."

Q. There is only one real solution to the pulpless tooth problem. What is it?

A. Prevention of toothache. Delivery of the message to the people: "YOU MUSTN'T LET YOUR TEETH ACHE." Fill cavities before they reach the pulp.

Q. What is the only real solution to locating incipient proximal caries and pyorrhea?

A. Periodic radiographic examinations.

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